MISSOURI

GEOLOGICAL SURVEY

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VOLUME IV.

PALEONTOLOGY OF MISSOURI

(PART I)

BY

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LETTER OF TRANSMITTAL.

MISSOURI GEOLOGICAL SURVEY,
JEFFERSON CITY, June 1, 1894.

To the President, Governor Wm. J. Stone, and the members of the Board of Managers of the Bureau of Geology and Mines:

GENTLEMEN—I have the honor to transmit herewith the first part of my Report on the Paleontology of Missouri.

With great respect,

CHARLES R. KEYES,

State Geologist.

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PREFACE.

Several years ago a systematic investigation of the Carboniferous faunas of the Mississippi basin was begun. Fossils from Iowa, Illinois, Missouri and the neighboring states were collected, and the work of examination, comparison and revision of certain groups undertaken. A large number of species were thus passed in review, and considerable progress made toward the monographic consideration of the forms of different genera. Many type specimens from various cabinets and museums were carefully examined, and accurate drawings made of those which had never been illustrated, or which had been poorly figured. Publication of the results of these studies had already commenced when opportunity was offered, through Mr. Arthur Winslow, State Geologist of Missouri, to modify, temporarily, the original plan, by bringing together all the material relating directly to the State in the form of a review of the Paleontology of Missouri for one of the reports of the Geological Survey. To the notes already accumulated which pertained directly to the subject, were added the results of special observations made at different times in various parts of the district. This report was practically ready for the press, and drawings prepared, nearly two years ago. Owing to various delays, chief among which was the preparation of other reports, it did not get into the printers' hands. During the two years which elapsed many new facts had been obtained and new material brought to light. In the meanwhile a change in the administration of the Survey occurred.

Immediately afterward the report was taken up, new material added, various parts entirely re-written and the entire work thoroughly revised, so that now it presents quite a different appearance from what it did when transmitted the first time.

For a long time there has been a wide-spread desire among certain classes of citizens for a more concise account of the organic remains of the State, especially in the light of the fact that fossils have such a distinct economic importance in determining the age of rocks, and hence serve as trusty guides in the further development of our mineral wealth. In the attempt to satisfy properly the demands arising in connection with a work of this character, it is the intention to present, as briefly as possible: (1) an index to the fossils of the State, through means of which the forms now known to occur within the limits of the region under consideration can be recognized readily, without recourse to great libraries; (2) a bibliography of Missouri Paleontology, bringing together all that has been written on the subject, now so widely scattered and practically inaccessible; (3) a summary of what has been done up to the present time in this branch of science, in so far as it pertains to the State of Missouri; and (4) an introduction to more comprehensive faunal studies, tending toward a solution of stratigraphical problems at present more or less obscure.

The material upon which the report is based has been derived from various sources. The greater part of the species illustrating the fossil faunas of the region has been collected by different members of the Geological Survey of Missouri. Supplementary to this a number of local cabinets in the State have furnished important series of particular groups. Another fertile field for valuable Missouri specimens was the many private collections belonging to persons residing outside of the State, and to which free access was generously given at all times. During the many years fossils have been collected in Missouri a considerable number of forms have found their way into the cabinets of various colleges and public museums. Altogether, these collections furnished an amount of reliable material that could not have been otherwise obtained in years of special work.

In the present memoir, every endeavor has been made to deal only with the species which have passed under personal observation. In this way, secondarily acquired information

has been largely eliminated; and with few exceptions, which have been duly noted in their proper places, all the species here considered have been personally handled. Every year brings forth discoveries of forms new to science, or which, though already known to occur in other political provinces, have not been observed before within the borders of the State. For this reason the work can never be regarded as fully completed, and must necessarily be supplemented in order to keep it up to date. It is hoped that this additional material may be incorporated from time to time in the form of special bulletins, as appendices of the present volume.

The fossil plants of the State will receive special elaboration in another place.

The general plan of treatment of the different species enumerated has been to give under each a more or less complete bibliography, by reference to which additional information or good illustrations of the forms not here figured may be found. In the diagnoses it has been the aim to give a rather full description of some leading representative of each genus, accompanied by a suitable figure; and to make the sketches of the other members of the group brief and in a great measure comparative. By this manner of dealing with the subject it is thought that the characterizations of all the species will be sufficiently ample for intelligent comprehension, and for the particular uses to which the work will be put. At the same time, the bulk of the report will be reduced very greatly—to one-fourth, at least, of what it would otherwise have to be. The horizon and some of the leading localities of each species are also given. The matter of localization has had to be rather general, allusion being made to the nearest postoffice usually, or in a few instances, as when the fossil is common and the distribution wide, merely to the county. With the greater portion of the material the exact bed, with reference to a particular section, has not been made known. Both in published and in manuscript lists large numbers of erroneous identifications were found. For these reasons minute faunal studies could not be included; nor are they desirable in a work of a general

character. The horizons are designated by the larger units of the several groups. As already stated, some of the collections, especially those made by members of the present Survey, have been carefully and accurately labeled with particular reference to the different beds of a detailed section of each locality. When these now isolated sections are properly correlated, as they will be as the work of the Survey goes on, much valuable material will be in hand for broad studies in the distribution of the different faunas. This investigation has already begun, and very important results are foreshadowed.

Brief nominal histories have been appended to the descriptions of many of the most important species, together with some of the most salient points brought out in the present investigation concerning the structural features of the various types.

In regard to illustration, the leading Missouri species of each genus has been figured, and also some of those forms heretofore described from the State, but never illustrated.

Little attempt has been made to deal, to any great extent, with the numerous and complex questions of synonymy—not, however, for reason of any inappreciation or under-estimation of their full significance and importance, but on account of an entire inappropriateness, in a publication of this character, of such necessarily prolix discussions. That there exists a burdensome and extensive synonymy in many of the zoological groups is only too well known to every student of ancient life; in fact, it is so manifest to everyone who has given the subject even a casual consideration, as to at once render apparent the cogent necessity of a careful and complete revision of most of the sections. The wide geographical distribution of some forms, and the concomitant changes of environment, may be referred to as among the chief causes of local variation of species. Notwithstanding the painstaking and conscientious labors of some of the earlier American writers on the subject, the question of specific range in time and space did not receive the attention in the beginning that it did subsequently, and there-

fore species were often based upon superficial, trivial characters, which are relatively unimportant as classificatory criteria.

In considerations involving problems of synonymy, which have arisen prominently during the progress of the work, every effort has been made to pass unbiased judgment in accordance with the merits of each individual case; and when any discrepancies have occurred, the respective authors have been given every benefit of the doubt. Through the kindness of the various owners, hereafter mentioned, a large number of type specimens were critically examined. Many questions of identity, previously doubtful, were thus satisfactorily settled. To be sure, in some instances the same test may appear seemingly to have decided similar questions in very different ways; but there have always arisen minor points in the one or the other which do not strike one forcibly at first, though when once attention is called to them, they can readily be seen to have an important bearing in attempting to do full justice.

Considerable surprise has been expressed at various times during the progress of the present work, especially by those somewhat interested in geology residing in the State, at the lack of effort made to describe new species. The reasons for this seeming inappreciation of "new" species are numerous. In the first place, the main-spring of action in the description of the large majority of the species now known has not been a keen desire to advance our knowledge on the subject, but rather to merely attach one's name to as many specific terms as possible. The great number of forms indifferently described from fragmentary material or without illustration of any kind, and the host of undoubted synonyms, only too fully corroborate this statement. Paper after paper has appeared, made up entirely of mere incomplete diagnoses of "new species." If some of them had been accompanied by even slight references to the morphological and geological relations, there might be a demand for this class of work. But such has not been the case in fully one-half of all the forms that have been named from North America. Many specimens have been so imperfect that even the family affinities, to say nothing of the generic

characters, can at best only be surmised. When fossils are so indefinite as these, it is exceedingly difficult to see their importance to geology, and further than indicating the possible presence of other genera in particular strata, or furnishing a clue to the probable occurrence of other forms when the morphological characters of a previously unknown individual cannot be made out, it certainly must have small value in geologic work. Ancient forms of life subserve two great ends: the one phylogenetic; the other stratigraphic. The first is purely biological in its bearings, and contributes to a better understanding of the great plan of life. The second is geological in its aims, and is of the utmost importance in the consideration of the broad faunal questions pertaining to correlation. Both require a more or less complete knowledge of the structural features of species before the fossils perform their highest functions. The value of a form, therefore, is proportional to the perfection of preservation and the correct interpretation of its anatomical nature.

The morphological facts already brought out by the investigation of fossil organisms is only suggestive of the vast and fertile field open to the student who directs his energies along this line. Thus intimately connected with biology, the results of the study of the material accumulated up to the present time cannot but give most valuable aid in making out the phylogenetic history of the living zoological groups. Indeed, the importance of this consideration cannot be overestimated in the attempt toward an understanding of a complete phylogeny of organic beings. Viewed from an anatomical and embryological standpoint, the dead become rejuvenated; the "curious stones" live; the rocks disclose the great plan of life. More lasting, more useful, more worthy of contemplation, are paleontological labors directed thus, rather than to the indiscriminate multiplication of species, to the mere description of curiosities.

Not less important is the recognition of the mutual dependence of paleontology and stratigraphy for the attainment of the highest and most accurate results in generalizations.

Heretofore these fields have been far too widely separated; and the work of the one has been carried on practically independently of the other, with often very erroneous conclusions.

During the past few years several hundred "new" species and a considerable number of genera have been described from the upper Paleozoic rocks of Missouri. And it is safe to say that more than two-thirds of this number have unquestionably been brought to notice before. Many of them are the commonest species, described and well illustrated years ago. The folly of such careless multiplication of names is only too apparent, and certainly needs severe condemnation. The manifest indisposition to look up the readily accessible literature also reflects sadly on the methods of the worker. At best, synonymy is ever in great danger of unnecessary augmentation, and always will receive sufficient additions without the wholesale, useless allotments that need not be mentioned. Only when it is impossible to refer forms to species already described does it become necessary, or desirable, to propose new titles. And in all cases considerable familiarity with the representative species is at all times helpful. Within the last decade the trend of paleontological thought has been toward the higher ends previously alluded to. Comparatively few new species have been made known of late, indicating clearly that the day of indiscriminate species-making is drawing rapidly to a close, and that the efforts of paleontologists are being directed into the more important channels, in ways more intrinsically valuable and more in harmony with the truly philosophic spirit of pure science. Thus it is that students, in dealing with problems pertaining to ancient life, have begun to appreciate more fully the direct bearing and close relations of this science to those branches treating of the structure of animals, and their distribution in time and space.

The treatment of the different zoological groups referred to in the present connection has not been the same. In order to carry out the main intent of the work, and still have it included within the limits originally planned, it has been necessary to condense greatly the consideration of many of the sec-

tions. The most characteristic forms of the various geological horizons, and the species which are little known, have been considered more in detail than other forms equally interesting and perhaps even more important. Certain large groups have consequently been very briefly alluded to. Such are the Polyozoans, Vertebrates, and various sections holding lower taxonomic ranks. For the determination of the geological age of rocks, the Polyozoans are practically of no value to the average citizen of the State. This class has therefore received but little study in the present connection—only the more important species being described, though a considerable number of other species are listed which have been reported from localities on the boundaries of Missouri in adjacent states.

The detailed discussion of the general stratigraphy of Missouri must be reserved necessarily for another time. In the present connection merely a brief stratigraphical outline is given, in order that the geological relations of the fossils may be more readily comprehended. Although many interesting facts relating to this subject have been brought to light during the progress of the present investigation, it has been thought best not to present them until other equally important problems have been solved, and then bring the whole together in a comprehensive treatment of the entire subject. The memoir is therefore practically a synopsis of the fossil remains at present known from the State; and in most cases the specific details have been necessarily confined mainly to short comparisons, usually in pointing out the diagnostic characters of each species.

Sincere thanks are tendered to Mr. Arthur Winslow, the late director of the Missouri Geological Survey, for the many kind attentions and suggestions which added zest and pleasure to the work during its early progress, and for freely offering every facility possible for the advancement of the report.

Special acknowledgments are also due: Dr. John H. Britts, of Clinton, who, for many years, has done much to advance paleontology by collecting large numbers of our coal plants, many new to science, and who, with one or two others, has

done more to further the development of the mineral resources of Missouri than any other citizen of the State; Prof. G. C. Broadhead, of the State University, former State Geologist, who, owing to his connection with the earlier Snrveys, is better acqnainted with the geology of Missouri than any other person now living; and Prof. E. M. Sheppard, acting president of Drury college, Springfield, whose wide experience in the southwestern part of the State has lightened, greatly, the work which was carried on in this section.

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CHAPTER I.

INTRODUCTION.

The economic value of fossils is commonly entirely overlooked. To the laity usually these remains of life are merely curious; to the specialist the interest in the ancient organisms is largely scientific. But with him who wills it, even a slight acquaintance with the true character of fossils enables the rocks to be read as a printed page. It is one of the best established facts in modern geological science that there is an intimate relation between mineral deposits and the surrounding rocks; hence the geological age of the particular beds becomes an important factor in the early attempts to develop new mineral districts. This suggestion again rests upon one of the cardinal principles of geology: that the geological succession of strata is determinable readily by the remains of life contained. Thus, in reality, fossils are labels on the rocks, telling man at a glance the age of the bed he is working, and providing him with the most reliable guides he could possibly secure to direct him to the layers most likely to contain the mineral sought. As a good illustrative example, it is well understood now that the coal of the Mississippi basin is confined to certain limited horizons, ordinarily known as the Coal Measures. In the limestones and shales overlying the Carboniferous strata, there are associated always certain very easily recognizable fossils that are characteristic of the formation, and are not to be found elsewhere. A very little study of these forms soon determines whether or not the rocks of any given district are liable to furnish coal. Yet every year large sums of money are wasted in both this and the neighboring states in the fruitless search for coal and other minerals in places where there is no possibility whatever of success. Everywhere throughout the

region, numberless abandoned diggings and deserted shafts tell of the useless expenditure and loss of capital that easily might have been avoided. In other cases the same tests applied would indicate the presence of valuable deposits in localities where they were little suspected.

Of late years the sciences have held an important place in the educational curriculum. Their role in training the physical, intellectual and ethical powers of the human mind for the attainment of pure culture, in its broadest sense, is now admitted universally to be second to none. For a long time the scientific branches which could be taught indoors held preference, for obvious reasons. But rapidly the field broadened. Botany and zoology soon became popular; and in a less degree also geology. The latter did not receive the attention that it might and should. Probably on account of a lack of satisfactory local information, on the one hand, and partly by reason of unfavorable situations, on the other, geological instrnction in the schools of the country has been neglected to a greater or less extent. In some places, however, considerable activity has manifested itself in the study; and its value has begun to be duly appreciated in the stimulation of the imagination, in the development of the youthful faculties for observation, and in the extension of the cultural powers of the intellect.

Now the State of Missouri is one of the most favored provinces in all the great Mississippi basin for the study of geological phenomena. A wide range of geological formations is represented, from the earliest or Cambrian to the close of the Paleozoic. All the larger towns and cities present unusually fine opportunities for studying the historical side of the question. The numerous railroad cnttings, the many quarries, and the extensive natural exposures along the deeply cut streams, afford good sections of the various layers. Scarcely any of these places do not contain fossils; and usually there is a great abundance of both species and individuals. These advantageous localities have already awakened an interest in the investigation of local geological features, and, as just intimated, there

is now a rapidly growing desire for more detailed information than is contained in the meager accounts of a quarter of a century ago, or than can be picked up by the individual unaided and alone.

But aside from the purely intellectual culture to be derived from the consideration of geological phenomena, there is another feature in the study that is well worthy of the most serious consideration, especially in the light of the pre-eminently utilitarian tendencies of modern education. The early geological information and methods acquired in the schoolroom lay the broad and solid foundations for the future engineer and artisan. They do much toward encouraging the intelligent development of the boundless resources which Nature has bestowed with lavish hand on a great state. At the same time they protect the citizen from the wiles of prowling speculators, so numerous in all localities where mineral wealth is developing rapidly.

The literature relating to the fossil organisms found in the rocks of Missouri is widely scattered, and to a large extent inaccessible to any one but the specialist. The few descriptions printed by the State were issued nearly forty years ago. The reports containing them were rather sparingly distributed, and during the period which has elapsed since their publication most of the copies have been lost, destroyed, or passed beyond the boundaries of the State. In the meantime the population has greatly increased, so that, even if the reports were all at hand, the supply would be inadequate. Only a small proportion, therefore, of the citizens can avail themselves of these volumes. A goodly number of descriptions have appeared in the transactions of learned societies, and have had a limited distribution, the larger share of which has been foreign. In many cases these sketches have been brief, unsatisfactory, and nearly all of them unaccompanied by illustrations. Much confusion, consequently, has arisen; and in many instances the same species has received several different names. The large majority of the fossils found in Missouri have been described and figured in the voluminous reports of other states, most of

them now out of print and difficult to obtain. In fact it would be almost impossible to secure a complete set of these publications, even insofar as they relate to Missouri. These volumes contain references both to the forms which were originally discovered in Missouri, and the species which were first found elsewhere but now are known to occur within the borders of the State. Other descriptions are scattered far and wide through various journals and other serials, both in English and in foreign languages. Besides, there are many short papers and more or less lengthy allusions incorporated in the long list of government publications, and in volumes whose existence is unknown to the majority of people. There is still another class of information which the public does not have the use of; this comprises a number of privately issued matters and personal correspondence, which, though it cannot be regarded as "published," in the general usage of that term by all scientists, is nevertheless of very great value.

The absolute inaccessibility to this vast amount of literature is probably the one great drawback in the consideration of ancient life and the related geological problems—one of the most fascinating studies open to the young and old alike of our country. It justly calls for something brief, comprehensible, and within the reach of all. Private enterprise cannot undertake such work, and it thus becomes the duty of the State to vouch for its accomplishment.

While the report embraced in the following pages cannot be regarded as a complete exposition of the fossil animals occurring in the several geological formations, it is thought that it will form a reasonably fair presentation of our present knowledge of the paleozoic faunas of the State. Missouri is an exceedingly rich field for the student of ancient life, as is attested by the large number of species described from the rocks within her borders, and by the great collections of specimens made at various times. A considerable proportion of the forms early described were not fully understood, and when first noted were unaccompanied by figures. During the third of a century which has elapsed since these remains were ori-

ginally brought into public notice, the type specimens have passed through many vicissitudes; some have been irretrievably lost; some have had their labels destroyed and now are mixed up indiscriminately with other material; and still others, if they exist at all, are totally inaccessible. It is with extreme difficulty, therefore, that many of these early recognized species can be identified with certainty. Collections from the type localities have removed all doubt in a goodly number of cases. In many instances species have been described from fragmentary material, and to a large extent can be ignored. Concerning a few of the species, however, doubt will always exist as to their true generic and specific affinities. With these little can be done except to arrange them among the spurious and doubtful forms. Most of the fossils described from the State in the official reports of neighboring districts and in the various scientific magazines are fully represented in the collections examined; while a large number of the species here annotated, though already recognized elsewhere, have not until now been recorded from Missouri.

Studies relating to fossil faunas, taken as a whole, have lately assumed very great importance in the correct interpretation of stratigraphical problems. Heretofore the great hindrance to considerations of this kind has been the chaotic condition of the nomenclature of species, and the multiplication of names for forms already well known. By a careful consideration of the questions of synonymy, a firm basis for invaluable faunal deductions will have been laid, and the complex, little understood phases of stratigraphy better made out. Not until all the described forms have passed carefully in review, and their genetic relationships determined with some degree of exactness, can faunal investigations acquire the full consideration they are entitled to; for under the circumstances which have long existed, any approach to unanimity of opinion regarding the distribution of species in time and space has been difficult to secure.

Fossils are of interest from three points of view: (1) biological, (2) geological, and (3) economical. The first two are

purely scientific in their nature; but they form the basis for an intelligent comprehension of the third department of the science. The last is popularly regarded as the only one of the three sections worthy of notice, since it is directly more useful than the others. This notion, however, is very misleading, for without a full consideration in the first place, from a purely scientific side, the usefulness of these guides to mineral wealth ceases to exist.

From the biological standpoint, the remains of ancient life are of first importance in their bearing toward the phylogenetic history of existing organisms. With the large majority of the living animals and plants, the relationships with one another can be made out only through forms now long extinct. Many large and interesting groups are not represented at all at the present day among the faunas and floras of the globe. A knowledge of their former existence is, therefore, of invaluable aid in the attempt to make more complete the conception of the great plan of life. There are, besides, isolated living forms whose genetic relations long remained enigmatical, until it was discovered that they were very abundant in ages gone by; for they proved to be the lingering remnants of once flourishing and long-lived tribes now on the verge of extinction.

The second great function of fossils in biology pertains to the geographical distribution of organisms in former periods of the earth's history, and to the range of forms in time. The former consideration refers directly to the present limits of animals and plants in space; the latter to the deciphering of the antiquity of the living zoological groups.

Broadly understood, the term "fossil" is applicable to any organic traces of life naturally entombed in the earth's crust. But the various ways in which the hard parts of organisms are preserved give them widely different values as stratigraphical criteria. Accordingly the most important phases are: First, when the hard parts have suffered only slight changes in chemical composition, with the loss of merely the animal matter and

perhaps a little of the lime. Second, cases in which there has been a more or less complete replacement of the original composition by some foreign material—as iron pyrite or silica, for example—through a process of infiltration. In these two instances the original structure of the tissues remains intact to a greater or less extent. Third, those in which the hard parts have been entirely removed, and the cavities thus left in the rock are completely filled with silica or some other substance—the external characters being commonly as well preserved as when infiltration takes place, but no microscopic structure is ever apparent. Fourth, a set of conditions much like the last, but the cavities not again filled by foreign minerals. Moulds of the outer surface frequently show the external characters and ornamentation perfectly; and good reproductions of the original forms may be easily made by taking wax, or gutta percha, or even plaster casts. Fifth, in which the remains are known only from internal casts, as among many gasteropods and lamellibranchs. The fine mud in which the organism was finally buried worked its way into the interior of the shell, eventually forming a compact cast of the inside. After the deposit had hardened into rock, the shell itself was dissolved away, leaving the inside impression intact. In many cases both the internal cast and the exterior mould are found together; but oftener when the cast occurs the outer impression is not at all perfect, and when the mould is good the internal cast is often composed merely of loose sand or clayey material, which falls into the bottom of the cavity when the hard parts pass away in solution. Sixth, when the evidences of life are in mere traces or indifferent indications. While these have no special value, either morphologically or stratigraphically, they serve to prove the existence of particular groups at certain horizons; and often they lead to the discovery of more important remains.

It is manifest that only the first three categories mentioned are of special use in detailed faunal considerations. The first and second kinds are the most satisfactory of all; but the third and fourth furnish many suggestive hints, particularly when

good artificial casts can be made. With the last two groups the geological importance, compared with the other sections, is usually small, and of course dependent directly upon the degree of completeness with which the structural features are capable of being inferred.

The ever-shifting continental shore-lines are the lines of sedimentation. On the existing sea-borders several general zones of life can be readily made out. In the stratified rocks of a geological province, the same geographical succession of forms is capable of being determined with greater or less distinctness. These ancient life zones correspond in a measure with the three general lithological features usually observable in passing from an old coast border seaward: (1) the coarse arenaceous deposits; then (2) the argillaceous area, farther outward; and finally (3) the limestones, extending into what are known to have been deep-water tracts. In the broad Mississippi province this arrangement of formations is well shown, especially in the case of the later Paleozoic.

The mode of preservation of the different fossils is therefore intimately dependent both upon the original character of the hard parts, and upon the lithological nature of the deposits in which the organic remains occur. In the first case, chemical change is apt to take place more easily in organs containing certain constituents than others. In the second instance, the physical condition of the rock is an important factor. Thus, certain molluscan shells containing a proportion of calcium phosphate in addition to the carbonate, as in Lingula, are preserved, while associated shells composed of calcium carbonate alone disappear entirely. Certain clay beds may be highly charged with the remains of organisms, while a sandstone, equally prolific of life originally, may allow the ready percolation of subterraneous waters, dissolving and carrying away rapidly the material composing the fossils. Also, many highly fossiliferous limestones, in the common process of dolomitization usually have the original characters of the fossils contained changed so that only the internal casts remain.

The basis of geological chronology, the sequence of the stratified rock formations of the globe, rests entirely upon the nature of the contained fossils. As a matter of course it is a comparatively simple thing to make out the true succession of the beds in any given locality, and to understand that ordinarily the lowest are the oldest and that the uppermost are the most recent. But the case is not so simple when the investigation is extended, when a comparison is made with similar exposures in distant places, for there are usually physical difficulties in the way in attempting to trace the separate layers or groups of strata through all intermediate points. When the sections are near together, the continuity of the different layers may be inferred from the lithological characters. But inasmuch as these constantly change, correlation by this method becomes the more uncertain according to the distance from the original locality. Finally, it becomes impossible to say whether or not the rocks of one place are older or younger than those of another, whether one lies above or below the other. For there are great beds of limestone, shales and sandstone identical in all lithological characters with other rocks, but separated by thousands of feet of strata representing enormous periods of time. Should the geological structure be such that two of these similar layers were nearly on a level, they might easily be taken for the same stratum, if the peculiarities of the rock components alone were relied upon. Now, it is the great service which fossils perform in acting as media of correlation in widely separated outcrops of rock, to show whether the beds of one region were contemporaneous with those of the other; to indicate which is the younger of the two deposits, and how much, in units of geological time. Everywhere on the globe, observation has shown that the general succession of organisms has been the same from the dawn of life to the present time. Thus does the conception of the genetic relationships of organic beings awaken a keen interest in the extinct forms of life, and furnish the key in deciphering the great book of Nature.

CHAPTER II.

GEOLOGICAL FORMATIONS OF MISSOURI

The stratified rocks of Missouri belong almost entirely to the Paleozoic system. From the northward as far down as the Missouri river, approximately, a great mantle of glacial detritus hides from view for the most part the more ancient rocks. In the southeastern corner of the state a small area is occupied by unconsolidated clastics of comparatively recent date.

Not taking into account the glacial deposits, the northwestern two-fifths of the state is made up of the youngest of the Paleozoic rocks—the Coal Measures; the south-central one-third of the province by the oldest stratified rocks—the great Magnesian limestone series. An arrow belt bordering the Mississippi nearly the entire length of the state exposes the Lower Carboniferous limestone; while a thin strip, between the oldest and youngest paleozoic sediments sparingly represents the great interval of time between the deposition of the two, which in other regions is filled by such enormous thicknesses of Silurian and Devonian strata. (See map.)

The chief topographical feature of the state has long been known in the Ozark uplift, a broad plateau with gentle quaquaversal slopes, rising to a height of more than 1500 feet above mean tide, and extending almost entirely across the southern part of the district. On all sides the borders of this highland area are deeply grooved by numberless streams flowing in narrow gorges. Against its nucleus of very ancient granites and porphyries the great "Ozark" series of magnesian limestone was laid down. Then the area occupied by these rocks was elevated, and around its margins were deposited successively the other members of the Paleozoic. The Ozark region was thus the first land to appear within the borders of the present state of Missouri.

The general sequence of geological formations is perhaps best shown in the subjoined table:

Table of Geological Formations of Missouri.

Age.	Series.	Stage.	Formation.	Thickness.
Quaternary		*Pleistocene*	Alluvium	25
			Loess	30
			Till	45
Tertiary		*Eocene*	Bloomfield sands	85
Carboniferous	COAL MEASURES	*Missouri*	Upper coal measures	1000
		Des Moines	Lower coal measures	600
	MISSISSIPIAN (LOWER CARBONIFEROUS)	*Kaskaskia*	"Chester" shales	120
			Kaskaskia limestone	100
			Aux Vases sandstone	50
		St. Louis	Ste. Genevieve limestone	150
			St. Louis limestone	210
			Warsaw (in part)	50
		Augusta	Warsaw (typical)	35
			Geode Bed	40
			Keokuk limestone	50
			Upper Burlington l	60
			Lower Burlington l	45
		Kinderhook	Chouteau limestone	75
			Hannibal shale	75
			Louisiana limestone	60
Devonian	UPPER	*Hamilton (Western)*	Callaway limestone	70
			Grand Tower limestone	100
Silurian	UPPER	*"Niagara" (Western)*	Clear Creek limestone	150
			"Niagara" limestone	40
	LOWER	*"Hudson River"*	Girardeau limestone	45
			Hudson shale	80
		Trenton	Trenton limestone	200
		Calciferous	First Magnesian l.	80
			Roubidoux sandstone	75
Cambrian	OZARK		Magnesian limestone	500
Algonkian			Pilot Kn. conglomerate	40
Archæan			Iron Mtn. Porphyry	300

ARCHÆAN ROCKS.

Near the eastern limit of the Ozark region, in Iron, Madison and eight or ten of the neighboring counties, there rises, abruptly, a group of bold, rugged hills, the best known of which are Pilot Knob and Iron Mountain. The altitude of these elevations is from 200 to 700 feet above the surrounding country. The hills are composed, chiefly, of massive crystalline rocks, consisting, principally, of granites and quartz-porphyries, cut in places by dykes of more basic material. They

are by far the oldest rocks known within the limits of the state of Missouri—much more ancient than any of the great series of sediments found in the region. There is now not the slightest doubt that these old crystallines are, for the most part, truly igneous; that they were once in a molten state, but long since cooled and became solidified.

In the present connection, further reference to the crystallines is perhaps unnecessary, yet they are of importance stratigraphically, in being the nucleus around which a great series of Paleozoic sediments accumulated in this part of the American continent.

ALGONKIAN FORMATIONS.

The succession of strata in the Ozark region of Missouri is but little understood as yet. There is certainly a great body of massive crystallines which are manifestly much more ancient than any of the sedimentaries which everywhere overlie them, and of which brief mention has just been made. Along with the granites are porphyries; then lie thick beds of conglomerate made up of porphyry fragments. Associated with these are certain slates and beds of iron ore.

The conglomerates are more or less perfectly bedded. Those occurring on Pilot Knob have been referred to by Van Hise and others as probably representing the Algonkian of the Lake Superior region and elsewhere. There are doubtless other conglomeratic deposits in the same district, which are contemporaneous with the Pilot Knob rocks; and on the other hand, many of the conglomerates were probably formed at the same time as the limestones and sandstones which surround the crystalline peaks.

That these truly eruptive rocks are more ancient than the surrounding sedimentary beds is shown chiefly by:

(1) An entire absence of contact metamorphism in the associated strata.

(2) Presence of angular fragments of the crystallines in the sedimentary beds abutting the igneous elevations.

(3) Presence of crystalline breccias between the horizontal limestone and massive rocks.

(4) Horizontal position of the stratified rocks on the uneven and manifestly eroded surface of the crystallines.

CAMBRIAN.

Ozark Series.

As already stated, the geological age of the Paleozoic formations of Missouri, from the top of the column down as far as the base of the Trenton limestone, has been determined satisfactorily. Below the calcareous division last mentioned is a great thickness of dolomitic limestones, with intercalated sandstone beds. They form what is commonly known as the "Magnesian Limestone" series. The lithological characters are very different from those of any of the later calcareous beds. Heretofore fossils have not been found abundantly in this formation; yet recent observations have indicated that extensive faunas will be disclosed before long in the rocks under consideration.

Although it has long been known that the Magnesian limestones are older than the Trenton, and that they lie immediately upon and against the Archæan crystallines uncomformably, their exact geological age has always remained unsettled. There seems to be but little doubt, however, that part of the series is equivalent to the Calciferous of other regions. It is also pretty well determined that certain of the lower beds, all below the "Saccharoidal" sandstone perhaps, are representatives of the upper Cambrian or Potsdam. These conclusions appear well grounded both upon stratigraphical and faunal evidence. The rocks of the Ozark region have not as yet received the necessary detailed study to enable the several lines of demarkation to be drawn with certainty. This investigation is now being carried on as rapidly as possible, and promises very satisfactory and interesting results in the near future.

The early geological reports represent the Magnesian limestone series as made up of seven members. Following Swallow, these may be briefly described in the present connection. Beginning at the top, they are:

GORGE OF THE MISSOURI RIVER AT JEFFERSON CITY.

First Magnesian limestone.
First, or Saccharoidal, sandstone.
Second Magnesian limestone.
Second sandstone.
Third Magnesian limestone.
Third sandstone.
Fourth limestone.

The "Fourth" Magnesian limestone, or lowest number of the Ozark series recognized, has its typical exposures along the Niangua and Osage rivers in Morgan and Camden counties. The basal grits, conglomerates and associated calcareous beds, underlying the Third Magnesian limestone in the Iron Mountain region, have been thought to be the shore representatives of this limestone, in part, at least. Perhaps, also, further research will reveal other strata below the lowest beds of the Ozark now known. According to the measurements of Swallow, the "Fourth" Magnesian limestone has an exposed thickness of more than 300 feet at the center of a broad anticline on the Niangna river.

Lithologically it is described as a buff, coarse-grained dolomite, similar to the other magnesian strata of the series, but with few cavities and very little chert. It is heavily bedded, and along the streams where exposed forms high mural escarpments and precipitous cliffs.

Of the "Third" sandstone little has been said. It is doubtless merely a local occurrence. So far as is known it has only been reported on the Niangua river in Camden county, where it attains a thickness of about 30 feet. Broadhead thinks that 82 feet of this sandstone were passed through in drilling the deep well at the Saint Louis County Insane Asylum.

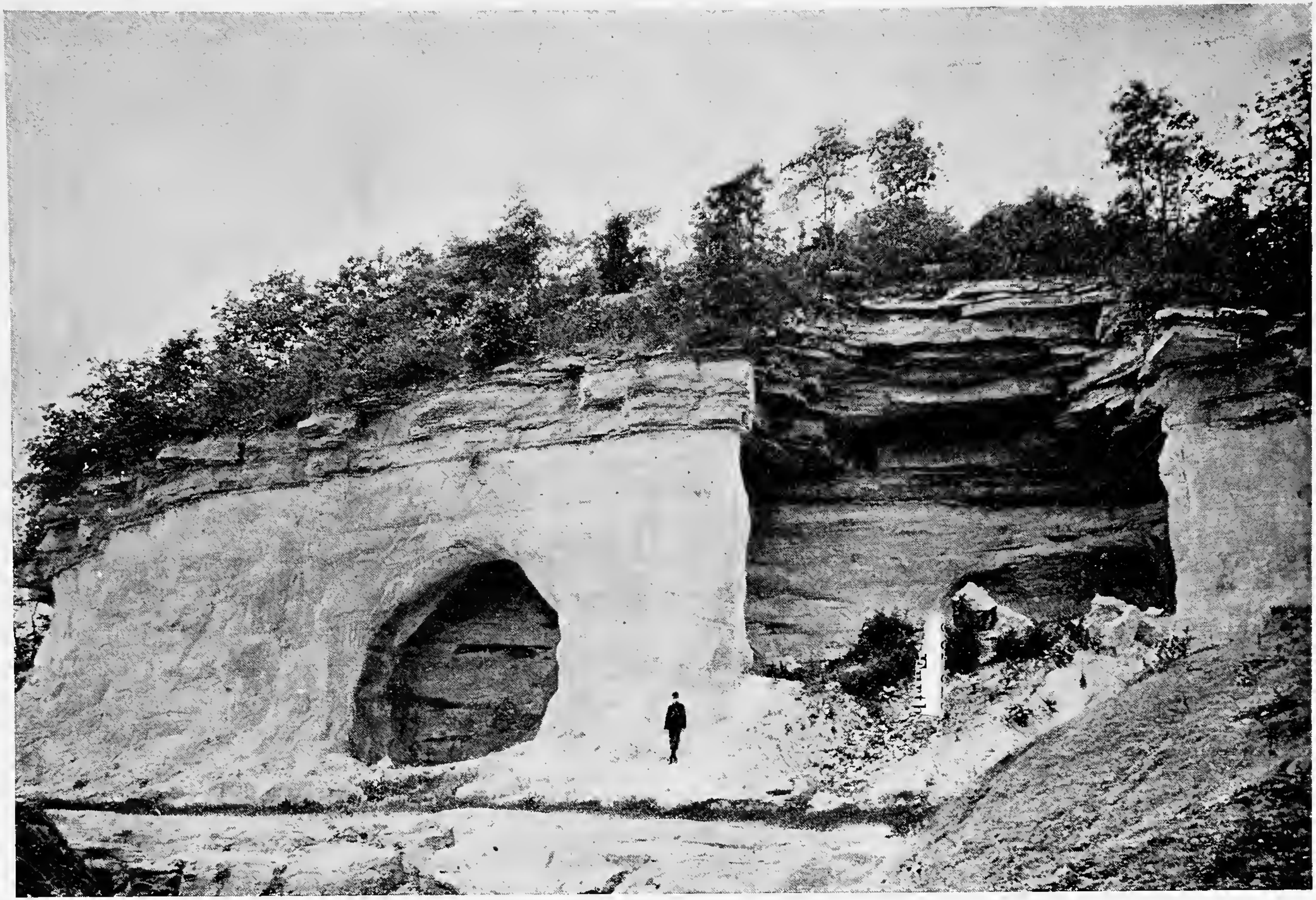
This sandstone is very massive, showing but little tendency, in weathering, to emphasize the lines of stratification. In many places, however, cross-bedding is well defined, indicating the shallowness of the water at the time of deposition. Usually the sandstone is very soft and incoherent, with little foreign material intermingled.

The "Third" Magnesian limestone has long been regarded as the lowest number of the series exposed over a greater portion of the Ozark uplift. It is a buff, rather compact dolomite, heavily bedded, with occasional chert layers, and is estimated to have a maximum thickness of about 400 feet.

Swallow's description of the "Second" sandstone is as follows: "It is usually a brown or yellowish brown fine-grained sandstone, distinctly stratified in regular beds, varying from two to eighteen inches in thickness. The surfaces are often ripple-marked and micaceous. It is sometimes quite friable, though generally sufficiently indurated for building purposes. The upper part is often made up of thin strata of light, soft, porous, semi-pulverulent sandy chert or horn-stone, whose cavities are usually lined with limpid crystals of quartz. Fragments of these strata are very abundant in the soil and on the ridges where this sandstone forms the surface rock. It sometimes becomes a pure white, fine-grained, soft sandstone." Thickness 50 to 100 feet. In portions of the rock are found chert bands containing imperfect fossils.

The "Second" Magnesian limestone is exposed in a broad belt around the Ozark uplift. It reaches a thickness of over 150 feet in places. Lithologically it is very much like the other limestones of the series, being composed chiefly of buff magnesian beds, usually fine-grained and compact in texture. Often there are intercalated layers of chert, sandstone or earthy limestone. Broadhead has regarded this formation equivalent to the Calciferous sandrock of New York; but the fossil remains thus far found are far too meager to enable its fauna to be made out with any degree of certainty. The character of the rock is well shown in the gorge of the Missouri, from Jefferson City many miles down the stream. (Plate i.)

In lithological characters the First or Saccharoidal sandstone is a white, fine-grained, homogeneous rock, very pure, friable, but withstanding the weathering influences in a remarkable manner. Locally it has a small percentage of iron, turning the stone to a brownish or reddish color. (Plate ii.)



SACCHAROIDAL SANDSTONE. PACIFIC.

Worthen regarded this sandstone as exposed on the Mississippi river at Cap-au-Gris, above the mouth of the Missouri, the representative of the Saint Peter sandstone of northeastern Iowa and the adjoining parts of Illinois, Wisconsin and Minnesota; but the correctness of this correlation is very doubtful.

Until quite recently, little additional information has supplemented Swallow's observations of forty years ago. Recent investigations in the field go to show that much confusion has existed concerning the different limestones and sandstones, and that, for instance, the "second" sandstone of one locality is not the "second" sandstone of other places. Furthermore, there appear to be good grounds for believing that there is a decided physical break between the "saccharoidal" sandstone and the "second" Magnesian limestone, though thus far the line of unconformity has been noticed at but few points.

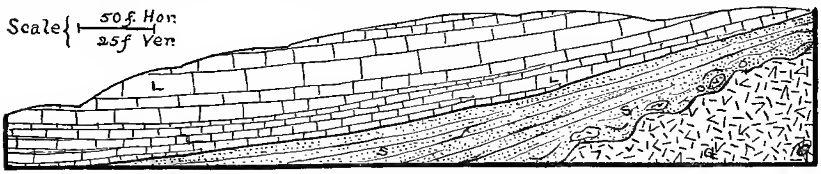


Fig. 1. Contact of Cambrian and Porphyry. Fredericktown.

Although personal study of the field relations of the different members of the "Magnesian limestone series" has not been as extensive as is to be desired, a careful comparison of both these notes and other references has given the impression at least that that part of the "series" below the "first" sandstone is to be regarded as one great limestone, or series of limestone beds, and that the sandstones are merely local facies, forming lens-shaped masses of limited extent.

In the Iron Mountain region the base of the series has been described as made up of grits, shales and limestones resting upon the crystallines. Exposures showing the line of unconformity are numerous. They indicate plainly that the conglomerates and sandstones are the immediate shore deposits, quite limited in extent and varying with every crystalline elevation. One of these sections along the Little Saint

Francois river, near Fredericktown in Madison county, is shown above. It may be taken as representative of a very large number of exposures occurring throughout the district. The porphyry is perfectly massive, rather dull reddish in color, with numerous dykes of diabase traversing it in various places. The interior of the mass is perfectly fresh. Over its ancient surface it has manifestly been greatly eroded, and is still covered with fragments and boulders of various sizes. The sandstones, with planes of false bedding distinctly marked and inclined at a high angle, pitch away from the central porphyritic elevations. A short distance from the crystalline masses, the sandstones, by the addition of calcareous material pass rapidly into heavily bedded limestones. This transition takes place both upward and laterally. In the former direction the change is often abrupt. The sand grains become fewer and fewer and more widely separated, until within the space of often three feet the passage from a pure silicions sandrock to a homogeneous limestone is complete. The evidence is plain that the great quartz-porphyry and granite masses of the region were raised above the waters of the great interior sea, and profoundly eroded as well as deeply decomposed *in situ*. When the hills were gradnally depressed below the level of the waters, the wave motion quickly removed all loose material on the surface, depositing it again near by along the sides of the old peaks. Sandstones and limestones, with occasional clays, thus filled the old valleys. When from any cause the currents became stronger, tongues of sand were deposited far out into the waters, again to be soon covered by limestone. Thus on the sloping, sinking shores sands were laid down. Their seaward extent varied greatly at different horizons—sometimes covering the calcareous deposits; sometimes allowing themselves to be covered. Thus closely following the ancient land surface, a continuous sandstone may be found, representing several or many horizons. Farther outward, or seaward, sandstone beds are found intercalated in limestone. This disposition of beds is graphically shown in the accompanying diagram. (Figure 2.)

UNCONFORMITY OF LOWER CARBONIFEROUS AND OZARK LIMESTONES.

It has been intimated that there is probably a well-marked physical break in the Magnesian limestone series at the top of the "Second limestone." The present indications point strongly to the supposition that the calcareous members of the series below the line mentioned practically form one great limestone formation, with numerous intercalated lens-shaped beds of sandstone, arranged largely perhaps as already explained.

For the entire Magnesian series—embracing the seven numbers of Swallow—Broadhead* has recently given the name Ozark.

If in future it seems advisable to separate the First Limestone and Sandstone from the underlying strata, Broadhead's

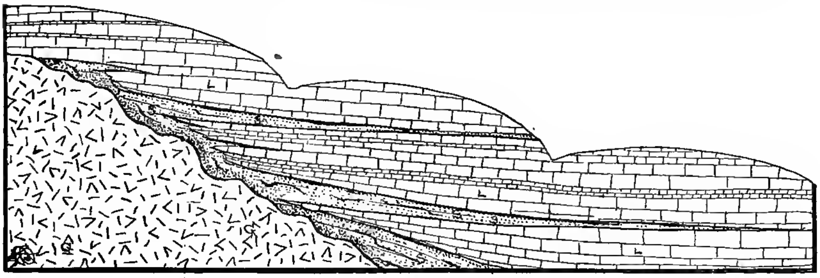


Fig. 2. Deposition of Ozark Rocks.

name by slight restrictions may still be retained to designate these rocks.

It appears quite probable that the "First Magnesian" limestone is the representative of the "Lower Magnesian" of the upper Mississippi region, the Saint Peter sandstone being absent in Missouri, or rather represented by calcareous deposits. As intimated previously, there seems to be considerable evidence pointing toward a line of unconformity between the Magnesian limestones below the "Saccharoidal" sandstone and that rock. This horizon below the Trenton would appear to be equivalent to the Chazy or upper Calciferous of the Appalachian districts. It may be regarded as made up of (1) a more or less interrupted sandstone forming the basal and marginal portion; and (2) a magnesian limestone having a very considerable geographic extent.

* Am. Geologist, Vol. VIII, p. 33. Minneapolis, 1891.

SILURIAN.

The lower Silurian rocks of Missouri are confined entirely to the eastern border of the state in the immediate vicinity of the Mississippi river. In the southeastern part of the district, where the entire series is fully exposed, there is a four-fold division—a median shale formation with heavily bedded limestones above and below. These members are:

Girardeau limestone.

Hudson River shales.

Trenton limestone.

First Magnesian limestone.

"FIRST MAGNESIAN" LIMESTONE.

This is usually a buff, heavily bedded dolomitic rock, not very compact, but withstanding well the effects of weathering. Its maximum thickness, as determined by Shumard, is over 150 feet. Swallow,* Broadhead† and others considered this formation as belonging to the Calciferous; while Worthen placed it in the Trenton. In attempting to correlate it with the series of the upper Mississippi river, it seems not likely that it is the representative of the lower Magnesian or Oneota limestone of that region; the Saint Peter sandstone being absent in eastern Missouri, or replaced by limestone as already remarked.

TRENTON LIMESTONE.

In southeastern Missouri the Trenton limestone as now understood embraces, besides the Trenton as comprehended in earlier reports of the state, the Black River and Birdseye limestones of Shumard. The latter probably more properly represents the lower and less fossiliferous portion of the Trenton of the region, and nowhere can be separated faunally or lithologically from the upper part containing the typical Trenton fauna.

The lower Trenton ("Black River" and "Birdseye" limestone) is a compact, heavily bedded limerock, often not unlike certain lithographic stones in texture.

*Geol. Sur. Missouri, 1st and 2nd Ann. Rep., p. 114. 1855.

†Geol. Sur. Missouri, 1873-74, p. 29. 1874.

The upper Trenton, or Trenton proper, is well exposed in all the counties along the Mississippi river from Marion to Cape Girardeau. In its northern extension it is chiefly a buff-colored or yellowish-gray limestone with occasional shale partings. Fossils are abundant in places, though often in the form of casts. Southward the limestone becomes compact, bluish-drab, with abundant fossils.

HUDSON SHALES.

Everywhere on the eastern border of Missouri, wherever the Trenton limestone is exposed, blue calcareous shales are found to overlie it. These shales rapidly disintegrate, upon exposure to the weather, into a soft plastic clay. Numerous thin seams of impure limestone are intercalated, and often form beds of considerable thickness. Fossils are abundant and well preserved. They are all very characteristic of the fauna occurring at Cincinnati, Richmond (Indiana), and in northeastern Iowa.

Upon lithological and faunal grounds, Swallow and Shumard early correlated these shales with the Hudson River shales of New York and Ohio. In 1868 Worthen* called these beds the "Thebes" shales, from the village of that name in southern Illinois, on the Mississippi river below Cape Girardeau. As defined by the Illinois geologist, the Thebes shales and sandstone form the lowest member of the Cincinnati group—the upper section embracing practically the same beds as the Girardeau limestone of Shumard†, but placed by the last author in the Upper Silurian. In the same region Shumard‡ had previously (though through delays not published until several years later) divided those shales into:

Upper Hudson shales	45 feet
Cape Girardeau sandstone..	35 feet
Lower Hudson shales...	50 feet

At Thebes the whole formation is well exposed in a sharp anticline, bringing up centrally the Trenton limestone above

* Geol. Sur. Illinois, Vol. III, p. 27. 1868.

† Geol. Sur. Missouri, 1 & 2 Ann. Rep., p. 154. 1855.

‡ Geol. Sur. Missouri, Rep. 1855-1871, p. 264. 1873.

the water level of the Mississippi river, and successively, on either side, all the beds of the Hudson shales.

North of the Missouri river, in Pike, Ralls and Marion counties, the lithological characters and fossils are essentially the same as in the southern part of the state.

GIRARDEAU LIMESTONE.

This rather well-remarked division of the lower Silurian in southeastern Missouri was first differentiated by Shumard in 1855, and provisionally called by him the Cape Girardeau limestone, but was regarded as a member of the Upper, instead of the Lower, Silurian.

Lithologically the limestone is bluish, very compact, and resembles somewhat the stones used in lithographing. It is rather thinly bedded, with numerous vertical fractures or joints. Fossils of peculiar types abound. Its thickness is over 60 feet.

Worthen* also recognized this formation as a distinct horizon, but made it the upper member of the Cincinnati group, the superior part of the Lower Silurian of the region.

UPPER SILURIAN LIMESTONES.

The rocks which in the Mississippi valley have commonly been referred to the Niagara have not been made out satisfactorily in southeastern Missouri, and they do not appear to be represented at all along the northern and western borders of the Ozark uplift.

At Louisiana, in Pike county, Mo., immediately above the Hudson shales, is a bed of white oolite five feet in thickness. It is overlain by a buff, dolomitic limestone, very massive, and having a vertical measurement of four feet. Two miles below the town this bed is ten feet thick, and still further to the south is said to thicken to upward of 30 feet. Above this layer are a few feet of dark-colored shales, containing apparently a well-defined Devonian fauna. Then comes the lithographic or Louisiana limestone.

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*Geol. Sur. Illinois, Vol. III, p. 26. 1868.

Regarding the geological age of the oolite, there appears to be considerable evidence that it belongs to what may be termed the western Niagara. The systematic position of the overlying buff limestone has not been determined with certainty, and its southward extension in Missouri has not been traced as yet. On the opposite side of the Mississippi river, in Calhoun county, Illinois, Worthen has reported a series of very similar sections between the Lower Silurian and Lower Carboniferous. There, however, there are two buff limestones above the oolite bed, each of which is much thicker than the buff layer at Louisiana. The upper of these two limestones carries a characteristic Devonian fauna. The lower layer grows rapidly thicker southward, and is regarded as continuous with a lithologically similar stratum exposed near the mouth of the Illinois river, which has lately yielded abundant typical Upper Silurian fossils.

The lithological and stratigraphical characters point to the correlation of the buff dolomitic limestone just referred to, as exposed at Louisiana, with the upper of the Illinois calcareous beds, or the Devonian. The fact also that the coral *Acervularia davidsoni* and similar characteristic Devonian fossils found in the neighboring localities, in Illinois, have been reported from above Louisiana, suggests that this series is actually represented on the Missouri side of the river. As the bed in question is apparently the only limestone from which Devonian fossils could be obtained, the inference is that the buff limestone above the oolite at Louisiana is probably Devonian rather than upper Silurian in age.

CLEAR CREEK LIMESTONE.

The term Clear Creek was originally applied by Worthen,* in 1866, to a series of limestones exposed along the Mississippi river in Illinois, in Union and the adjoining counties, with a stratigraphical position immediately above the Lower Silurian. Subsequently † the name was restricted to the upper portion and

* Geol. Sur. Illinois, Vol. I, p. 126. 1866.
† Geol. Sur. Illinois, Vol. II, p. 8. 1866.

regarded as lower Devonian in age—the lower part being referred to the Lower Helderberg.

As described by Shumard * in the geology of Cape Girardeau county, and also in the geology of Perry county†, his Niagara and Delthyris shales correspond in part to Worthen's Lower Helderberg of the adjoining districts. The upper portions of the Clear Creek limestones may finally be placed in the Devonian, but the lower portion ("Lower Helderberg") certainly is Upper Silurian, and probably corresponds, in part, to the so-called Niagara of Indiana and elsewhere.

These limestones attain a maximum thickness of probably 400 feet. They are easily distinguished in the eastern parts of Ste. Genevieve, Perry and Cape Girardeau counties, where they form high rural escarpments along the streams of the region. They are rather light-colored, grayish or bluish limestones, with considerable chert in layers. Fossils abound in certain beds.

DEVONIAN.

GRAND TOWER LIMESTONE.

In southeastern Missouri, the Devonian rocks are as yet but little understood. They have been subdivided and correlated with the New York section; but it is quite manifest that any apparent parallelism is merely coincidental, and does not represent any real relationship. The upper limestones clearly contain the so-called Hamilton fauna of the West, and very properly may be regarded as representing the "Hamilton group" of the adjoining states. The name here used is intended to apply to the Devonian rocks of southeastern Missouri, exposed best perhaps in the vicinity of Grand Tower, below those beds containing the fossils of the Western Hamilton. These rocks have been referred chiefly to the Onondaga and Oriskany by Meek and Worthen and others. The fauna contained seems to differ very considerably from the typical Western Hamilton of other parts of the Mississippi basin.

* Geol. Sur. Missouri, 1855-71, p. 261. 1873.

† Ibid., p. 231.

CALLAWAY LIMESTONE.

In southeastern Missouri, rocks containing the typical fauna of the Western Hamilton are sparingly represented in Perry and Cape Girardeau counties, in connection with the limestones mentioned above. In this region the limestones belonging to this group are dark-colored, shaly rocks, quite different from the associated strata.

North of the Ozark uplift the Devonian rocks referred to the Hamilton extend westward along the Missouri river as far as Jefferson City, having their most typical development in Callaway county. In several places abundant fossils of this formation have been obtained from strata having lithological characters not very unlike the beds of the eastern Ozark region referred to the same age.

At Winfield, in Lincoln county, near the line of the so-called Cap-au-Gris fault, the Western Hamilton limestone containing numerous characteristic fossils, is inclined at a high angle, about 75°. The beds lean against beds of the great Magnesian limestone series.

The limestone beds at Louisiana, near the probable northernmost surface extension of the Devonian rocks in Missouri, have already been discussed under the Niagara group. The thin beds of clay-shales at the same place, particularly the uppermost sandy layers containing abundant fossils, are considered at length further on, in connection with the remarks on the Lithographic limestone.

CARBONIFEROUS.

Lower Carboniferous, or Mississippian, Series.

In the great interior basin of the Mississippi the basal series of the Carboniferous is exposed more or less continuously over broad areas, extending from northern Iowa to Alabama, and from Ohio to New Mexico. In lithological characters the rocks contrast sharply with the overlying members of the system—the first being chiefly compact, highly fossiliferous limestones; the second principally clay-shales and sandstones.

For this lower calcareous portion the term "Subcarboniferous" has been applied usually; but, as will be seen hereafter, there are serious objections to the use of this name. "Mississippian series" has heretofore been employed as a substitute in the present connection. The name was originally suggested, in nearly this sense, by Alexander Winchell, and has been recently somewhat modified and applied by H. S. Williams.*

More than half a century has passed since the rich and varied faunas of the later Paleozoic rocks of the continental interior first began to attract attention. From the beginning, an exceedingly active and ever-growing interest was taken in the various forms of ancient life represented, and as a matter of consequence the geological history of the region was approached from the biological rather than the stratigraphical side. Especially was this the case along the line of the Mississippi river, where the most important exposures of the strata in question occur.

The relations of the most important horizons of the lower Carboniferous in the upper Mississippi valley were early made out by Owen and others; and although Owen's views underwent radical modifications during the dozen years that he was engaged in studying these rocks, his subdivisions have been practically the basis of all subsequent classifications. In the main they have been adopted everywhere, notwithstanding the fact that a considerable diversity of opinion has always existed in respect to the minor stratigraphical details.

In the naming of the several assemblages of beds, the leading and most widely known terms that have been applied have been taken from localities situated on the "Father of Waters." The Mississippi section therefore becomes the most important of all in the correlation of the Lower Carboniferous rocks of the great interior basin. For this reason it was that recently all the original localities were visited, the various exposures examined in detail, and their relationships with each other and with the overlying and underlying strata particularly noted.

*Bul. U. S. Geol. Sur., No. 80, p. 135. 1891.

The nominal history of the major subdivisions of the Paleozoic of the Mississippi basin need not be reviewed in this place. Suffice it to mention that the term Subcarboniferous had in the beginning a very different meaning from what it has had of late years. As originally proposed by Owen,* the name was used merely to indicate an indefinite series of limestones below the coal-bearing strata of the interior. Subsequently the same author limited the formation below to the blue fossil-bearing limestones, now known as the Cincinnati beds. It was in 1847, when Owen and Norwood † gave the "black slates" as the upper limiting member of the Devonian, that "Subcarboniferous" was still further restricted; thus for the first time giving the name "Subcarboniferous" the meaning which has been generally attached to it of late years.

The most familiar names assigned to the subdivisions of the Carboniferous along the Mississippi river are: Chouteau, Kinderhook, Burlington, Keokuk, Warsaw, Saint Louis, Sainte Genevieve, Chester, Kaskaskia and Coal Measures.

Typical Sections Along the Mississippi River.

A few of the most characteristic sections have been selected for notice here, and their lithological details briefly explained. By comparison with the general section on the accompanying plate iv, the stratigraphical relations according to the present understanding may be indicated in the briefest possible manner. These sections are taken at places where the most minnte and satisfactory information has been obtained, and they assume their names from these localities. They are all marked on the general section (plate iv).

* Researches on the Protozoic and Carb. Rocks of central Kentucky during the year 1846. 1847.

† Rep. Geol. Rec., Indiana, 1837, p. 12. 1839.

I. Burlington Section.

		Feet.
10.	Limestone, impure, somewhat clayey, thinly bedded, with chert nodules and seams	20
9.	Limestone, gray, coarse-grained, encrinital, with occasional clay partings and some flint	30
8.	Shales, buff, calcareous and silicious, with thin limestone and flint bands	23
7.	Limestone, brown and gray, encrinital, compact and heavily bedded, with thin clay partings	27
6.	Limestone, rather soft, buff, probably somewhat magnesian, apparently sandy locally	6
5.	Oolite, gray	4
4.	Sandstone, soft, fine-grained, yellow, highly fossiliferous	6
3.	Limestone, gray, impure, fragmentary, with often an oolitic band below	9–13
2.	Sandstone, soft, fine-grained, bluish or yellowish, clayey, passing into sandy shales in places	20–30
1.	Clay-shale, blue, fossiliferous, shown by borings to extend 50 to 100 feet or more below the water level (exposed)	50

All beds below No. 6 are regarded as Kinderhook. Nos. 7 and 8 are the lower Burlington limestone; Nos. 9 and 10 the upper Burlington limestone.

II. Keokuk Exposures; Tabor's Saw-mill.

		Feet.
9.	Drift and Loess	10
8.	Sandstone, soft, brown or yellowish, passing into a fine-grained conglomerate in places, irregularly cross-bedded, and lying unconformably upon the next (exposed)	10
7.	Limestone, blue and ash-colored, brecciated, indistinctly bedded locally, and passing elsewhere into regularly bedded layers	25
6.	Limestone, brown, impure, arenaceous, heavily bedded	4
5.	Shale, blue, calcareous, clayey	10
4.	Limestone, impure, massive, weathering brown	7
3.	Clay-shale, with occasional limestone bands and abundant little crystal grottoes—the "geode-bed"	35
2.	Limestone, thinly bedded, somewhat shaly	5
1.	Limestone, blue, encrinital, heavily bedded and more or less highly fossiliferous (exposed)	45

Below No. 4 of this section is the Keokuk group of Hall; 4 to 6, inclusive, form the Warsaw, of the same author; while No. 7 is the Saint Louis limestone reposing unconformably upon the brown massive layer No. 6, and with the Coal Measures, No. 8, superimposed unconformably upon it.

III. Warsaw Section.

		Feet.
6.	Limestone, ash-colored, brecciated	25
5.	Gritstone, buff, calcareous, fossiliferous	8
4.	Clay-shale, blue, with thin bands of impure limestone	25
3.	Limestone, compact, buff, with encrinital layer above	6
2.	Clay-shale, blue, "geode-bed"	30
1.	Limestone, thinly bedded, encrinital, highly fossiliferous (exposed)	15

Nos. 1 to 5 are regarded as Keokuk; of these, Nos. 3, 4 and 5 are the typical Warsaw of Hall. No. 6 belongs to the Saint Louis.

IV. Louisiana Exposures.

		Feet.
15.	Soil	2
14.	Limestone, compact, yet thinly bedded, encrinital, with considable gray and brown chert	50
13.	Limestone, massive, white, encrinital, coarse-grained	12
12.	Limestone, brown, encrinital, with irregular chert bands and thin clay seams occasionally	20
11.	Limestone, very heavily bedded, white, encrinital	11
10.	Limestone, brown, encrinital, somewhat sandy in places; earthy and disintegrating on exposure to the weather	10
9.	Limestone, fine-grained, buff	8
8.	Shale, brown, sandy	12
7.	Shale, green	60
6.	Limestone, thinly bedded, compact, buff, in layers from 4 to 6 inches in thickness, with a thin and sandy highly fossiliferous seam at the base	50
5.	Clay shale, blue	2
4.	Shale, black, fissile	4
3.	Limestone, compact, massive, buff	10
2.	Limestone, gray, oolitic	5
1.	Shale, blue, with numerous thin limestone bands, rich in fossils (exposed)	60

All above No. 9 belong to the Burlington limestone; the beds Nos. 6 to 9, inclusive, are Kinderhook, 9 being the Chouteau limestone of Swallow; Nos. 7 and 8 the Vermicular sandstone and shale of the same author, and No. 6 the lithographic limestone.

V. Saint Louis Section.

	Feet.
Limestone, blue and gray, compact, rather heavily bedded, more or less highly fossiliferous, with thin marly partings (exposed to water level)	125

VI. Sainte Genevieve to Sainte Mary.

8.	Soil	3
7.	Sandstone, soft, yellow, ferruginous (exposed)	15
6.	Clay-shale and heavily bedded blue limestone	125
5.	Sandstone, yellowish (Aux Vases river)	70
4.	Limestone, bluish, thinly bedded (Sainte Genevieve)	45
3.	Limestone, rather heavily bedded, blue and ash-colored, with marly partings, showing cross-bedding in places; oolitic and cherty locally	135
2.	Oolite, white, fossiliferous	15
1.	Limestone, massive, compact, white in color and highly fossiliferous (exposed)	50

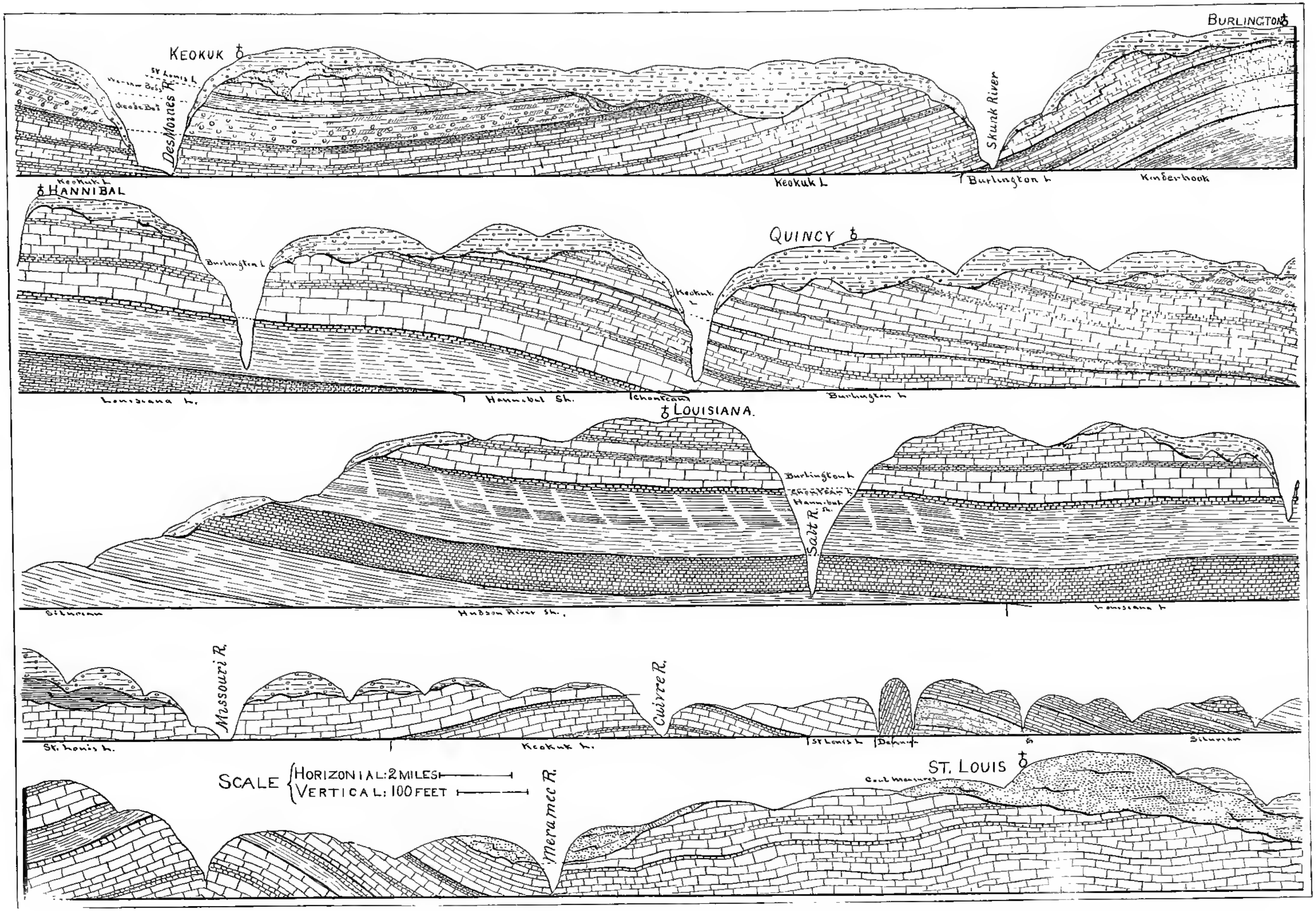
No. 1 is probably upper Keokuk; Nos. 2 to 4 belong to the Saint Louis group; No. 6 is the Kaskaskia. No. 7 is the basal sandstone of the Coal Measures.

VII. Chester Section.

		Feet.
8.	Sandstone, ferruginous, with plant remains (exposed)	25
7.	Shale, green and blue, with occasional limestone bands	10
6.	Limestone, gray, more or less nodular and impure	45
5.	Shale, green and blue, with thin limestone layers, highly fossiliferous in places	45
4.	Limestone, heavily bedded, compact, encrinital, with clay partings	3
3.	Shale, drab, fossiliferous, with thin calcareous seams	4
2.	Limestone, dark drab, compact	4
1.	Limestone, heavily bedded, blue and gray (above water level)	75

KINDERHOOK BEDS.

Definition—There seems to be a general unanimity of opinion as to the propriety of regarding as a distinct subdivision the Lower Carboniferous rocks of the Mississippi basin below the Burlington limestone. The upper line of demarkation is easily recognizable throughout its whole geographic extent. Its lower limit, however, has not been made out satisfactorily over the entire area of its occurrence; but in many places the group of strata is known to rest on the "black shale" so well developed in Tennessee, and generally regarded as Devonian age. For the groups of the beds in question, or parts of the group, various names have been given. But their historical consideration need not be dwelt upon at length here. Whatever may be, eventually, the most appropriate term to apply to this sec-



PRINCIPAL MISSISSIPPIAN SECTION.

tion, it seems advisible for the present to retain Meek and Worthen's name for these rocks as exposed along the line of the Mississippi river.

Among the earliest references to the rocks of this group in the continental interior is that made in connection with Owen's explorations in southeastern Iowa.* This author called some sixty feet of ash-colored shales exposed above the level of the water in the Mississippi river to the base of the encrinital limestone at Burlington the "argillo-calcareous group," and regarded it as belonging to the lower part of the Subcarboniferous. These shales were actually a portion of the median member of what Swallow† in Missouri had termed the "Chemung" group. This group was divided into (1) the Chouteau limestone, (2) the Vermicular sandstone and shales, and (3) the Lithographic limestone. Within the limits of the region under consideration the three divisions are quite persistent and easily recognizable over wide areas. The last two members have recently been termed, and very appropriately, the Hannibal shales and the Louisiana limestone respectively, since at the places in northeastern Missouri bearing these names they are exposed in their full development.

Throughout Iowa, Illinois and Missouri, at least, and perhaps in other states also, wherever the Kinderhook rocks are exposed, its members, as here designated, will always be recognized to a greater or less extent as convenient stratigraphical unit, particularly in faunal studies. Over all three of the states named these subdivisions are sharply defined lithologically, except possibly toward the northern known limits, though there the rocks have received comparatively little or no attention. At the present time it seems very probable that the third or lowest member—the Louisiana or Lithographic limestone—will find a closer relationship with the Devonian than with the Carboniferous, and that eventually it will be regarded as the capping stratum of the former over all the territory contiguous to the Mississippi.

* Geol. Sur. Wisconsin, Iowa and Minnesota, p. 92. 1852.

† Ann. Rep. Geol. Sur. Missouri, p 103. 1855.

In 1858 Hall continued to regard the Burlington (Iowa) section below the oolite layer as Chemung. But he also included in the group some yellow sandstones occurring fifty miles to the northward, which Calvin* has recently proved conclusively to be of Devonian age.

Although Owen had referred the shales lying immediately below the limestone at Burlington, Iowa, to the Subcarboniferous (limited) more than a decade previously, Meek and Worthen † in 1861 were the first to prove beyond a doubt that the faunas of the rocks along the Mississippi river between the cities of Burlington and Saint Louis, and lying between the "black shales" and the Burlington limestone, have much closer affinities with those of the overlying strata than with those below, and therefore the rocks in question properly belong to the Lower Carboniferous series. The name "Kinderhook" was then proposed for the formation.

Soon after, Worthen ‡ published further details, especially in regard to the typical locality, Kinderhook, Illinois. Various sections in the neighborhood were fully described, leaving no doubt as to the exact limits that were intended to be assigned to the formation. On the opposite side of the river, in Missouri, the exposures are practically continuous for more than 30 miles, and show well the relations from the "black shales" to the upper division of the Burlington limestone.

In the Iowa section, White ‖ recognized as Kinderhook the Burlington rocks previously called Chemung, together with a few feet of what was once considered as belonging to the superimposed stratum.

The "Chouteau" group takes its name from the leading member of the three-fold division, the Chouteau limestone. The application in this sense was first proposed by Broadhead,§ who used the term to cover the same limits as Swallow's "Chemung" in the earlier Missouri reports. Very recently

* Am. Geologist, Vol. III, p. 25. 1889.

†Am Jour Sci., Vol. XXXII, p. 228. 1861.

‡Geol. Sur. Illinois, Vol. I, p. 108. 1866.

‖Geol. of Iowa, Vol. I, p 192. 1870.

§Geol. Sur. Missouri, p. 26. 1874.

the name apparently has been extended by Williams* to embrace also the lower Carboniferous littoral deposits (Waverly grits, etc.), as well as the more open sea depositions of argillaceous and calcareous material (Kinderhook shales and limestone).

From the foregoing it appears that in the states bordering the Mississippi river, the term Kinderhook has priority in the naming of the inferior member of the Lower Carboniferous as now generally understood. Whether or not Waverly or Marshall, as rocks of probably the same age in Ohio and Michigan are called, should replace Meek and Worthen's name, remains to be seen. These probably represent the littoral deposits of the more westerly limestones just referred to. Both lithologically and faunally, they are sufficiently distinct from the western deposits to make a separate designation for them desirable, at least for the present.

Louisiana Limestone.—The Louisiana limestone (Swallow's Lithographic) is exposed best perhaps at Louisiana, in Pike county, Missouri, where it attains a maximum thickness of more than 60 feet. As its early name suggests, its texture is very similar to that of the stones used in lithography, being very fine-grained, compact, and breaking with a sharply conchoidal fracture. In color it is usually ashen, often with a bluish tinge. But these characters do not persist throughout its range. According to both Swallow and Broadhead, it becomes elsewhere coarse-grained, less homogeneous and more heavily bedded than at the typical locality. It is usually rather thinly bedded, the layers being from four to six inches in thickness, and wherever exposed stands out in high, rural escarpments, with every appearance of artificial masonry. (Plate V.) The lower layers are more or less arenaceous, and yield numerous fossils. At Louisiana this limestone rests on a dark, clayey shale, whose thickness is about six feet, and this again on a compact, buff, magnesian limerock, probably of Silurian age.

In southwestern Missouri this division of the Kinderhook has received but little attention, and its true relations as yet

*Bul. U. S. Geol. Sur. No. 80, p. 169. 1891.

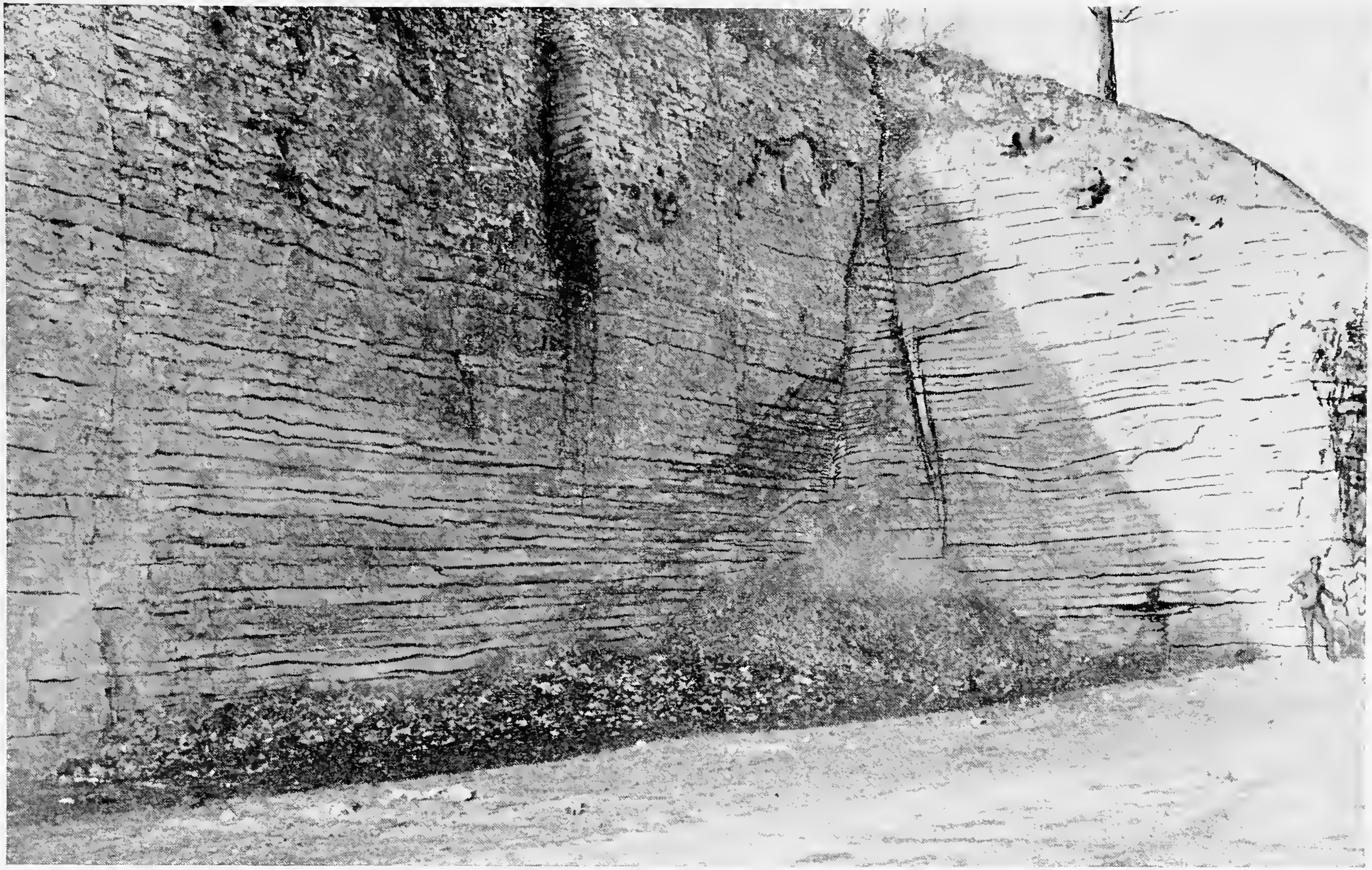
have not been made out very satisfactorily. At every locality where it has been reported in this region, its lithological characters are very different from those in the more northern districts, and its stratigraphic relations are for the most part somewhat uncertain. However, Shumard reports it capping hills of the Magnesian limestone series in Ozark, Douglas and Wright counties, and overlaid by sandy shales containing typical Kinderhook fossils. Broadhead also believes it to be recognizable in Cedar and Saint Clair counties; while Swallow states that 30 feet of it, preserving its characteristic texture, are exposed in Jasper county.

Although for many years past the Kinderhook beds have been regarded as the basal part of the Lower Carboniferous (or Mississippian) series in the upper Mississippi valley, a decided Devonian facies of the contained fossils has always been observed. This peculiar faunal aspect has occasioned much comment, and has attracted wide notice. So much were some of the earlier geologists impressed with this character of the organic remains, that they hesitated but little in referring the beds in question to the upper Devonian.

The best exposures of Kinderhook rocks are found along the Mississippi river at Burlington, Iowa, Kinderhook, Illinois, Hannibal and Louisiana, Missouri. At all of these places the lithological characters are practically the same, except perhaps toward the more northern part of the exposed range, where the upper part is changed somewhat, and the lower portion does not rise above the water-level. At Louisiana the exposures are perhaps more open to observation than elsewhere; though for 70 miles along the river the outcrop is practically continuous. The vertical section has already been given in another place.

In 1852 * Owen, who was the first to give attention to the geological details of the rocks as exposed along the "Father of Waters" above the mouth of the Missouri, limited, as already stated, the term "Subcarboniferous," which hitherto had long been applied to all the strata below the Coal Meas-

* U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 92. 1852.



TYPICAL EXPOSURE OF LOUISIANA LIMESTONE. LOUSIANA.

ures down as far as the Hudson River shales, to what practically is now known as the Lower Carboniferous or Mississippian series. The Louisiana or Lithographic limestone was not included; for his "Argillaceous Martites" seem to have been regarded as the basal member. Swallow,* Hall† and White,‡ who were well acquainted with the section and its fossils, correlated the beds immediately below the Burlington limestone with the Chemung (Devonian). In northeastern Missouri and adjoining portions of Iowa and Illinois, the "Chemung" included the Chouteau limestone, Vermicular shales and Lithographic limestone. Hall, who had studied more particularly in Iowa, erroneously regarded certain sandy shales or yellow sandstones, just below the great limestone at Burlington, identical in age with a lithologically similar rock 50 miles to the northward, at the mouth of Pine creek, in Muscatine county, Iowa. The latter, as has been stated, has recently been shown by Calvin || to belong to the Hamilton group, as known in Iowa. Consequently Hall, having investigated the more northern locality more thoroughly perhaps, very naturally came to the conclusion that the entire formation under consideration as he understood it was actually Devonian. But as already shown, the rocks of the two localities are widely separated in point of time.

Meek and Worthen, § who had considered chiefly the fossils in the upper part of the so-called "Chemung," both at Burlington, Iowa, and Kinderhook, Illinois, a few miles from Hannibal, Missouri, regarded the fauna to be more closely related to the Carboniferous than to the Devonian. Since the publication of these views, writers upon the subject have accepted them, and they have been adopted in the geological reports of Illinois, Missouri and Iowa.

By reference to the vertical section already given, it will be seen that the commonly known Kinderhook of this region

* Geol. Sur. Missouri, Ann Rep, p. 101, 1855.
† Geol. Iowa, Vol. I, p. 99, 1858.
‡ Proc. Boston Soc. Nat. His., Vol. XIII, p. 289, 1862.
|| Am. Geologist, Vol. II, p. 25, 1889.
§ Am. Jour. Sci., (2), Vol. XXXII, p. 167. 1866.

is a three-fold division, the upper and lower being limestones and the middle one clay or sandy shale. At Burlington the fossils heretofore noted have been found in the upper portion of the formation; though very recently an extensive and interesting fauna has been discovered in the clayey portion much lower down. Here the lower calcareous member is not exposed. At Louisiana and vicinity the median member is practically unfossiliferous, as is also the lower, except at the very base.

It will be recalled that Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarksville principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, Hall, White and Winchell. It will also be noted that most of these forms have a very decided Devonian aspect which gives a peculiar and characteristic physiognomy to the faunas of the three beds. Heretofore little mention has been made concerning the exact horizon of the fossils in question, mere reference to the "Lithographic" limestone or Kinderhook beds being considered sufficient. Lately, however, extensive collections of fossils have been made at all three places just mentioned, as well as many intervening and neighboring exposures. Everywhere the Lithographic or Louisiana limestone has been found to be essentially devoid of organic remains, except an occasional form in the thin sandy partings above the bottommost layer, which is less than one foot in thickness. At the very base of the limestone is a thin seam of buff, sandy shale, seldom over three or four inches in thickness. This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of the Western Hamilton. The sandy seam is underlaïd by six feet of dark argillaceous shale, which has been regarded as part of the Devonian "black shale" of the Mississippi basin. This in turn rests upon fifteen or more feet of buff magnesian limestone and oolite, of Upper Silurian age, probably.

Lithologically, the thin sandy layer is more closely related to the underlying shales than with the overlying limestone. Faunally, it has very much nearer affinities with the Western Hamilton (Devonian) than with the Kinderhook (Lower Carboniferous). In Iowa the "Devonian aspect" of the Kinderhook faunas has disappeared, largely, since Calvin's recent discovery that the "Chemung" sandstones of Pine creek, in Muscatine county, Iowa, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view, almost completely, by eliminating the species found in the thin sandy seam at the base of Louisiana or Lithographic limestone. The faunas of the Devonian and Carboniferous of the upper Mississippi valley thus become more sharply contrasted than ever. The apparent mingling of faunas from the two geological sections, manifestly, was based upon erroneous assumptions rather than upon the detailed field evidence.

Depriving the "Lithographic" limestone, which attains a thickness of more than 60 feet at Louisiana, in Pike county, Missouri, almost entirely of the extensive fauna commonly ascribed to it, and which, as has been seen, comes from a thin seam lying below the calcareous layer, its geological age becomes a problem yet to be solved. The few fossils known from the limestone itself have been heretofore rarely met with. It is not at all unlikely that the lower limestone of the Kinderhook eventually may prove to be of Devonian age. But until abundant evidence to this effect is found, it seems advisable to still consider the Louisiana (Lithographic) limestone as the basal member of the Carboniferous.

It appears also very probable that a marked unconformity exists between the Carboniferous and Devonian rocks of the area just referred to, instead of a regular sequence of strata as has been usually supposed. The proofs of this statement, however, are not such at present as to warrant a definite formulation of the evidence; yet many facts recently obtained point strongly toward this conclusion, while the sharply contrasted faunal peculiarities are in themselves very suggestive and remarkable.

Hannibal Shales. — The Hannibal Shales (Vermicular shales of Swallow) have a maximum thickness of more than 70 feet at the typical locality iu Marion county (plate VI). They are fine bluish or greenish argillaceous beds, often with considerable amounts of calcareous and magnesian carbonates, forming in places impure earthy bands of magnesian limestone. The upper portion usually contains much fine arenaceous material, passing locally into sandy shales, shaly sandstones, and to the northward especially substantial sandrocks suitable for ordinary masonary. The indurated sandstones are largely absent in the southwestern part of the State. Downward the shaly sand-beds lose their arenaceous character and pass rapidly into the greenish clay shales, which appear remarkably uniform over broad areas. At Burlington, Iowa, recent excavations show a thickness of more than 70 feet, while borings indicate a vertical measurement of double that figure.

These shales attain their best development in Marion, Ralls and Pike counties, and in the contiguous districts of Illinois. From this place they pass southeasterly and southwesterly in a broad curved belt around the Ozark uplift.

In southeastern Missouri the exact equivalents of this formation are not definitely understood. In Ste. Genevieve county, certain variegated clay-shales below the Burlington Limestone have been referred to the Vermicular of Swallow. Worthen has also regarded as Kinderhook a series of argillaceous and silicious variegated shales found immediately above the "black shale" of the Devonian, in the adjacent parts of Illinois.

Westward from the typical locality, the Hannibal shales become more calcareous and much thinner, in some places apparently unrepresented, while the Chouteau rests directly upon the Ozark series of magnesian limestones. This thinning of the formation in question seems to be due in a large part to a low anticline tending northwest and southeast through Pettis, Morgan and Camden counties. The origin of the fold probably dates back to a period soon after the deposition of the last of the Ozark series. South of the anticlinal

axis just mentioned, the strata correlated with Hannibal shales partake more of the character of a soft magnesian limestone, but so earthy that it should not perhaps be termed limestone. It contains some of the lead and zinc ores of the district, which are now being extensively mined. On Pierson creek, seven miles southeast of Springfield, in Greene county, more than 40 feet of this formation is exposed in mine shafts. It is overlaid by 35 feet of typical buff limestone (Chouteau), over which is the lower Burlington, here highly fossiliferous. In Ozark, Douglas and Wright counties Shumard has called attention to isolated patches of these shales with abundant and characteristic fossils; and they are well developed in Polk county. They cap the highest hills of the great Magnesian limestone series, suggesting that the entire formation has been mostly removed, through protracted erosion, from this part of the State, perhaps as far northward as the Missouri river.

Chouteau Limestone—the upper member of the Kinderhook—is a fine-grained, compact limestone, buff in color, and usually more or less impure from an admixture of clayey material. At Hannibal and Louisiana it has a thickness of from 10 to 15 feet, apparently thinning out rapidly northward. It is probably represented at Burlington, Iowa, by a few feet of buff, calcareous layers lying at the base of the great limestone at that place. At Legrand, in Marshall county, Iowa, 50 feet of buff magnesian limestone immediately underlying the Burlington may perhaps be a northward extension of the Chouteau. Southward, in Missouri, the bed in question increases in thickness until it attains a measurement of 100 feet or more at Sedalia, and about 80 feet in the vicinity of Springfield, in the southwestern part of the State. Near Ste. Genevieve there are probably from 75 to 100 feet of this limestone. It is quite possible that in the northwestern part of this State, far below the Coal Measures, this limestone attains a much greater thickness.

AUGUSTA LIMESTONE.

In a paper entitled "Carboniferous Echinodermata of the Mississippi Basin," published in September, 1889,* it was pointed out upon purely paleontological grounds, as well as for lithological and stratigraphical reasons, that the Burlington and Keokuk limestones should be included under a single title, at least along the line of the Mississippi river where the typical exposures occur. At that time no name was proposed, for the reason that it was not thought advisable until further investigation was extended southwestward and southeastward from the original localities, and the exact relations made out between the rocks as shown in the latter place and those of distant regions referred to the same age. Quite recently, however, Williams† has suggested for this long-needed term "Osage." This is the name of the river of western Missouri which cuts through the lower Carboniferous series as represented in Saint Clair county.

As stated in the more recent publications in which the name has appeared, "Osage" has been used for the Burlington and Keokuk rocks of Missouri only provisionally—until more detailed information could be obtained. The term Osage does not now appear applicable, in the sense in which it was originally proposed, to the rocks of the Mississippi basin under consideration. The Osage river, from which the name is taken, flows for a greater part of its length through limestones of the great Ozark series (Cambrian or Lower Silurian). The upper part of the river passes through Coal Measure beds almost entirely. Only a very small portion of the water-course touches the Lower Carboniferous at all. The "Osage country," by al Missourians especially, is a term applied to the region along the lower part of this stream. At Osceola, where the most typical section of the "Osage" is exposed, the rocks appear to be as typical Burlington as at the city of Burlington itself. Recent visits have disclosed no Keokuk whatever at the place

*Keyes: Am. Jour. Sci., (3), Vol. XXXVIII, pp. 186-193. 1889.

†Bul. U. S. Geol. Sur., No. 80, p. 109. 1891.

in question. One of the chief reasons for proposing Osage was that the beds of southwestern Missouri were thought to contain a mingling of faunas of both Burlington and Keokuk beds. Insofar as personal observation goes, the Kinderhook, Burlington and Keokuk beds are as sharply contrasted lithologically, faunally and stratigraphically as in southeastern Iowa.

From the foregoing it would seem that the "Osage" formation at its typical locality is practically coextensive, and therefore synonymous, with the Burlington limestone. Southeastern Iowa has long been regarded as the typical locality of the rocks under consideration. There these beds have been described more in detail and are better understood than in any other region in which they occur. Since the Burlington and Keokuk limestones manifestly form a single epoch in the geological history of the region, as has been conclusively shown a number of times recently; since a term applicable to these rocks as a whole is desirable; and since the name "Osage" is apparently unavailable, it has appeared best to adopt for the title of this formation the name of some locality in southeastern Iowa where the rocks are well exposed. Along the Skunk river, in the vicinity of Augusta, about 10 miles southwest of Burlington, there is exposed the entire succession of these rocks, from the Kinderhook shales to the "geode bed." This name, therefore, seems more appropriate to use than perhaps some other better known term. Good exposures of the formation are found all along the Mississippi river from Keokuk to Burlington, as already mentioned. The limestone often stands out in overhanging cliffs over the softer Kinderhook beds, as is well shown in the vicinity of Burlington and elsewhere.

The term Augusta, for the formations under consideration, has already been used and adopted in Iowa, and its application in Missouri is equally appropriate.

Owen's encrinital limestone embraces, practically, the same beds that were afterward called the Burlington; and his lower Archimedes corresponds to Hall's Keokuk group below the geode bed. Shumard seems to have used the term " encrinital

limestone" in a variety of senses—sometimes referring to the Burlington alone, sometimes to both Burlington and Keokuk, and often to the Burlington and a part of the Keokuk. Partly on lithological grounds, but chiefly for paleontological reasons, the Augusta may be regarded as made up of three members—upper, middle and lower—coinciding essentially with the Keokuk and the upper and lower Burlington limestones. In regard to the fossils of the three horizons, the most conspicuous general differences were first suggested by White*, and quite recently† they have received further attention. These differences may be reiterated here. Those species from the lower Burlington are of small size, delicately constructed and highly ornamented. In the upper division of the Burlington the peculiar delicacy so characteristic of the forms of the lower bed is absent or has assumed a ruder phase, while in the Keokuk the crinoids are notable for large size, rough and massive construction, bold and rugged ornamentation, and a conspicuous exaggeration in many structural details. The last named consideration is of great interest, since it appears that in general the exaggeration of anatomical features is indicative of important biologic changes in that particular zoological group in which such extreme developments take place.

It is apparent from a close study of the crinoids, and in a somewhat less marked degree, perhaps, among other zoological groups, that there was an abrupt change of physical conditions at the close of the Keokuk epoch. For, at this time, more than one-half of the Carboniferous genera of this class had become suddenly extinct.

As already stated in another place, the abrupt extinction of a large proportion of the crinoidal and other forms of life at the close of the Keokuk is certainly suggestive of a series of wide-spread changes in the geographic and bathymetric extent of the great interior sea; and there is sufficient evidence to indicate that at the close of the Keokuk, the northern coast line of the broad shallow gulf which occupied the area moved

* Jour. Boston Soc. Nat. Hist., Vol. VII, pp. 224-225. 1860.

†Keyes: Amer. Jour. Sci., (3), Vol. XXXVIII, pp. 191-192. 1889.

LOVERS' LEAP, HANNIBAL.

rapidly southward, and this movement was soon followed by slight depression. The Saint Louis waters then pushed northward again, in some places several hundred miles.

Burlington Limestone—The lithological characters of the Burlington limestone are remarkably constant over broad stretches of territory. At the original locality it is a coarse-grained encrinital limerock; hard, compact and heavily bedded in some layers, porous in others, with scarcely enough of firm and cementing material to hold the crinoidal remains together. In some places, however, it is very compact, fine-grained and earthy, and is then reddish or deep brownish in color. Chert nodules abound locally. The lower portions are usually much more heavily bedded than the upper—the partings of the inferior beds being commonly a coarse, calcareous reddish sand, while in the upper strata, clay seams are not infrequent.

In western Illinois, in Pike and Marion counties, Missouri, in the southwestern and central portions of the same State, the lithological nature of this formation is the same. (Plate vii, hills capped by Burlington limestone.) In Greene county, in the southwestern part of Missouri, the upper and lower divisions are as well marked faunally as they are in southeastern Iowa. In fact, the two divisions at both localities are in all respects so near alike, that a person investigating and collecting at Springfield and Ash Grove could not tell but that he was in the environs of Burlington city itself, if he did not actually know that he was nearly 300 miles away. But the Burlington fauna, in all its entirety, is found much farther to the southwestward—as far at least as the Lake Valley mining region of New Mexico, though there the lithological characters of the strata are somewhat different. For the most part the geographical distribution of the Burlington limestone is west of the Mississippi river. East of the stream the typical exposures of the rock are unimportant, and unknown beyond the immediate vicinity of the great water-course.

In the most northeasterly counties of Missouri a shallow syncline carries the Burlington limestone below the level of

the river; but it rises to view in the southern part of Lewis county, above Quincy.

For more than 70 miles, from above Quincy to below Louisiana, the Burlington limestone forms an almost continuous mural escarpment, capping the high bluffs on either side of the Mississippi river. These bluffs rise to a height of from 300 to 400 feet above low water. In many places they form bold overhanging cliffs, with a heavy talus at the base. At the southern end of the escarpment the limestone is everywhere underlain by about 200 feet of shale and soft strata, which rapidly disintegrate, leaving the more durable overlying beds standing out boldly.

From Quincy southward the strata rise very gradually until the Burlington limestone, which appears a few yards above the water level at that place, has an elevation of more than 250 feet above the river at Louisiana. Below the limestone it will be seen from reference to the section that the beds are largely soft shales, which succumb to eroding agencies much faster than the great thickness of heavy compact limerock overlying. High hills with precipitous slopes are found there capped by the more indurated layers. They rise in almost vertical walls from about midway up the elevations. In consequence of this, a peculiar and very striking phase of topography is produced, reminding one very forcibly of the topographical effects in the great driftless area of northeastern Iowa and the adjoining parts of the neighboring states.

North of Quincy, as has already been stated, the Burlington rock dips below the water level of the Mississippi, and does not appear again until just above Fort Madison, in Iowa, while at the city of Burlington the base of the limestone is nearly 100 feet above the low-water mark. At this place the organic remains have received more attention than anywhere else; while the vertical range of the different species has been determined with great accuracy. From this locality, also, the extensive faunas of the Kinderhook were made known and many species described. But more than a third of a century has passed since the investigations of Hall, White and Win-

chell brought to light so many interesting forms which characterized the beds immediately below the Burlington limestone. At Burlington, too, the Burlington and Kinderhook formations are sharply contrasted lithologically; and faunally the two horizons are equally well defined.

Passing southward 100 miles to Louisiana, Missouri, the same lithological and faunal features are found as at Burlington. These characters are shown for 50 miles along the great river in this vicinity.

In the lower bed of the Burlington limestone is found the typical and well-marked fauna of this formation. Many of the species, however, have a somewhat greater vertical range than at the Iowa localities. Among the most characteristic species of leading types of the life of the period may be mentioned:

Orophocrinus stelliformis, Owen & Shumard.
Cryptoblastus melo, Owen & Shumard.
Granatocrinus projectus, Meek & Worthen.
Rhodocrinus wachmuthi, Hall.
Rhodocrinus wortheni, Hall.
Agaricocrinus brevis, (Hall).
Dorycrinus unicornis, (Owen & Shumard).
Dorycrinus subaculeatus, (Hall).
Batocrinus æqualis, (Hall).
Batocrinus longirostris, (Hall).
Batocrinus elegans, (Hall).
Actinocrinus proboscidialis, Hall.
Actinocrinus tenuisculptus, McChesney.
Physetocrinus ornatus, (Hall).
Steganocrinus sculptus, (Hall).
Steganocrinus araneolus, (Meek & Worthen).
Platycrinus americanus, Owen & Shumard.
Platycrinus burlingtonensis, Owen & Shumard.
Platycrinus discoideus, Owen & Shumard.
Platycrinus subspinosus, Hall.

The fauna of this bed (about 11 feet in thickness) is primarily a crinoidal one. The above mentioned forms are some of the most important marking this limited horizon. Many other crinoids, as well as brachiopods, corals and gasteropods, are mingled; but they range upward into the other layers more or less extensively.

Above this bed is a slightly thicker member, of an intensely white color. It is encrinital chiefly, like the other, but in addition contains a large amount of comminuted shell material derived from molluscan remains. In places the shell fragments predominate, forming a fine shell breccia, not unlike the well-known coquina rock of Florida. It is, however, so compact that good specimens of fossils are almost impossible to dislodge. The layers of this bed contain also considerable chert in small nodules and nodular bands. When first exposed in quarrying, these cherts are very compact, translucent, and break with a conchoidal fracture. Upon exposure these flints quickly slacken like quicklime to a fine, intensely white powder. If examined before the process of disintegration has proceeded more than half way, the white nodules are found to be charged with fossils, which, when taken out, cannot be told from plaster-of-Paris casts. Before being affected by atmospheric agencies, few or no traces of organic remains are to be detected in the cherts. But they actually contain a very extensive assemblage of fossils, and in a perfect state of preservation when collected at the right time. They afford unusual opportunities for both structural and systematic studies, for many of the features commonly not met with are here found beautifully preserved. Such are the internal characters of crinoids and brachiopods, and the delicate ornamentation of nearly all groups.

Careful comparisons of the fossils from these cherts and those of the surrounding limestones show that the forms to a great extent are identical. Moreover, numerous shells and crinoids are found partly imbedded in the chert and partly in the limestone, with a sharp line of separation, indicating clearly that the silicious impregnation was acquired long after the original deposition of the beds, and was not due to a greater silicity of the waters in which the calcareous deposits were made, as has been held by many prominent writers. This is in accordance with observations made elsewhere in the Burlington limestone.

LOUISIANA TOPOGRAPHY.

The faunal aspects of the bed in question are particularly interesting. Some of the more common as well as the more important species may be enumerated as follows:

Goniatites osagensis, Swallow.
Phanerotinus paradoxus, Winchell.
Capulus paralius, White & Whitfield.
Capulus formosus, Keyes.
Porcellia nodusa, Hall.
Loxonema prolixa, White & Whitfield.
Spaerodoma penguis, (Winchell).
Pleurotomaria sp ?
Omphalotrochus springvalensis, White.
Holopea subconica?, Winchell.
Straparollus ammon, White & Whitfield.
Euomphalus luxus?, White.
Murchisonia sp.?
Bellerophon bilabiatus, White & Whitfield.
Allorisma hannibalensis, Shumard.
Edmondia nuptialis, Winchell.
Edmondia burlingtonensis, White & Whitfield.
Conocardium sp.?
Lithophagus occidentalis, (White & Whitfield).
Aviculopecten circulus, Shumard.
Lingula melie, Hall.
Discina newberryi, Hall.
Terebratula rowleyi, Worthen.
Productus arcuatus, Hall.
Productus lævicostus, White.
Productelia shumardiana, (Hall).
Rhynchonella missouriensis, Shumard.
Spirifera peculiaris, Shumard.
Strophonema rhomboidalis, var.

The forms in the accompanying list are all species which characterize the Kinderhook of Burlington, Iowa, and most of them were originally described from that place. In addition, many other species of lamellibranchs, brachiopods and gasteropods, which occur very abundantly at the latter locality, are found in the white chert of Louisiana, along with a few of the Burlington limestone species.

It is to be noted that:

(1) The fauna of this horizon is predominantly molluscan, presenting a marked contrast to that of the typical Burlington limestone, which is principally crinoidal, with comparatively few brachiopods.

(2) That the fauna is the typical fauna of the Kinderhook shales.

(3) There are mingled in this fauna some of the forms found both above and below, which are there associated with species characteristic of the lower Burlington limestone.

Here, then, is a well-defined Kinderhook fauna intercalated in the Burlington limestone, with practically no change of lithological characters; a lower fauna suddenly appearing in the midst of a higher. This is the most marked instance of the kind that is at present known in the Carboniferous of the Mississippi valley. Though the separation is not very great, the present case is a striking illustration of Barrande's celebrated Doctrine of Colonies, so clearly developed in his System Silurien du Centre de la Boheme,* and so ably defined in his Defense des Colonies.

It is not to be inferred, however, that during the short supremacy of the lower fauna, in the midst of an upper, there was a complete extinction of the deposed forms, but rather, that owing to peculiar conditions the lower fauna merely displaced the upper temporarily, or pushed it aside into other districts for the time being.

As far south as Ste. Genevieve county the Burlington beds still preserve their characteristic integrity. In the central part of the State the formation is well exposed in at least eight or ten counties. It forms the surface rock at and around Sedalia. In the northern part of Morgan county numerous small outliers of this rock are found on the highest hill-tops, resting directly upon the Ozark series. On the Osage river it is well developed, resting upon a thin layer of Chouteau, and this, again, upon the old Magnesian limestones. Southwestward from the last locality the Augusta group has not, as yet, received very much detailed study, except in Greene county, where, as already mentioned, the Burlington is well defined in all its characteristic peculiarities.

Keokuk Limestone.—The upper member of the Augusta has its distribution chiefly on the eastern side of the "Father of

*Vol. I, p. 73. 1852.

Waters," covering a wide area, in Illinois, Indiana, Kentucky and Tennessee. West of the river the most typical exposures are in southeastern Iowa and northeastern Missouri.

As exposed in the vicinity of the mouth of the Des Moines river, the upper part of the Keokuk is composed of argillaceous shales with limestone bands, while the lower portion consists of heavily bedded, compact, bluish limestones. These lithological characteristics, as well as its faunal peculiarities, extend southwestward as far as the Sedalia anticlinal axis, which, as has been previously stated, extends northwest and southeast through Pettis, Marion and Camden counties. Along this line the Lower Carboniferous rocks occur only in the central part of the first mentioned county. The upper members of the Ozark series are exposed everywhere in the southeastern portion of Pettis, and extended northward in the shallow creek beds to within a few miles of Sedalia. Directly upon the old Magnesian limestone series rests the Chouteau, though in places this is absent, and the Burlington limestone is the uppermost rock exposed. At Sedalia the Chouteau limestone is quarried at various places in the vicinity of the town. Usually a few feet of the very lowest bed of the Burlington are exposed. West of Sedalia a few miles the Lower Coal Measures begin, and coal pockets are found in depressions of Chouteau limestone. It will be inferred from the foregoing that in Pettis county the Lower Carboniferous is not represented above the Lower Burlington. The higher members of this series may have been removed through erosion during Carboniferous times. But it is more probable that they were never deposited here. It is a significant fact that down to the line of the Sedalia axis, the Keokuk, in its typical lithological and faunal development, is well defined. That southward, according to those who have visited the southwestern part of the State, all its characters are different.

The presence of the Coal Measures in Pettis county is manifestly an overlap, and the deposits contemporaneous with the Keokuk may be represented beneath the Upper Carbon-

iferous strata, and extend around the Sedalia elevation into the southwestern part of the State.

In southwestern Missouri, however, although typical Keokuk has been observed in a few places, the information is not as satisfactory as would be desired. The encrinital limestone of that region, which has been thought by some to represent both Keokuk and Burlington limestones of the more northern localities, appears to be the latter alone. Extensive collections of fossils made in various parts of the formation show few species that can be regarded as belonging to the true Keokuk. This is all the more remarkable from the fact that the vertical section of the Kinderhook and Burlington beds of this region is essentially identical lithologically, as well as faunally, with the one in northeastern Missouri. The several localities just referred to in which the Keokuk fossils have been found, show the faunas of the two members of the Augusta as well marked as in southeastern Iowa, and nowhere has there appeared a mingling or mixture of species more pronounced than at the typical places to the north.

In Greene county, where the rocks of the Lower Carboniferous have been more satisfactorily studied than in any other district of the region, the Chouteau limestone and underlying shales are exposed in nearly all the creek beds from the eastern border to the western. At Ash Grove on the western line of the county, the Chouteau and Lower Burlington are exposed near the railroad station. On the hill-tops a few miles to the westward, in Dade county, the Upper Burlington with a large fauna is found. As the rocks of the Lower Carboniferous in these and the adjoining counties dip westward at a low angle, about the same as the general slope of the present land surface, and the Coal Measures appear a short distance beyond the last named locality, there is evidently much ground for believing that in its full and characteristic development, the upper member of the Augusta may not be exposed here. Still, it may be present, for the recent personal investigations were not conclusive enough to preclude its existence entirely; and it may be well represented farther to the southwest.

Those who have personally collected and investigated in the middle portions of the Lower Carboniferous rocks of the southwestern part of Missouri have all found great difficulty in attempting to divide the Augusta limestone in the same manner as in the northeastern portion of the State. Whenever mention has been made of the Keokuk, in connection with the encrinital limestones of this region, it has always been in the most vague and uncertain manner. Of late years, collectors who have visited the southwestern lead and zinc districts have assumed that there the Burlington and Keokuk faunas are mingled or blended so as not to be distinguishable. In accordance with the idea, various field names have been given by different collectors to the rocks as developed in this part of the State, the most prevalent one now being "Cherokee." The same idea is embodied in the selection of the designation "Osage" for the group, a geographic name pertaining to this region.

As already shown in another place, insofar as the Burlington is concerned there is, in Greene and Dade counties especially, as well as in other neighboring districts, an Upper and Lower Burlington fauna identical with, and as well defined as, the two faunas are at the typical locality in southeastern Iowa.

Warsaw Beds.—The Warsaw beds as defined by Hall* and as exposed at the village of Warsaw, Illinois, are composed (1) 10 feet of compact, buff-colored limestone at the base; (2) 30 feet of blue calcareous shales with thin limestone seams, and (3) 8 feet of yellow arenaceous limestone. At Keokuk, five miles above, all three layers are thinner, and at neighboring places they exhibit still different characters. Southward the beds lose their argillaceous nature, and appear not to be separable from the associated limestone. These layers together with the "geode bed," which is usually considered the upper member of the Keokuk, may be regarded as mere local developments, to which little importance is to be attached. In a quarry a short distance northwest of Rand park, at Keokuk, Iowa, there is a good exposure showing the upper surface of

*Geology of Iowa, Vol. I, p. 971. 858.

the buff arenaceous limestone to be water-worn and weathered; and directly upon the eroded rock rests 20 feet of brecciated limestone. Whether or not this can be regarded as a portion of an ancient land surface, older than the Saint Louis limestone, depends partly upon the results of further investigation, and partly upon the final decision as to the origin of the brecciated rock. Gordon, who has recently given special attention, is inclined to regard arenaceous member as the base of the Saint Louis.

At Hall's typical locality it is manifest that the Warsaw beds are properly the superior portion of the Keokuk lime-

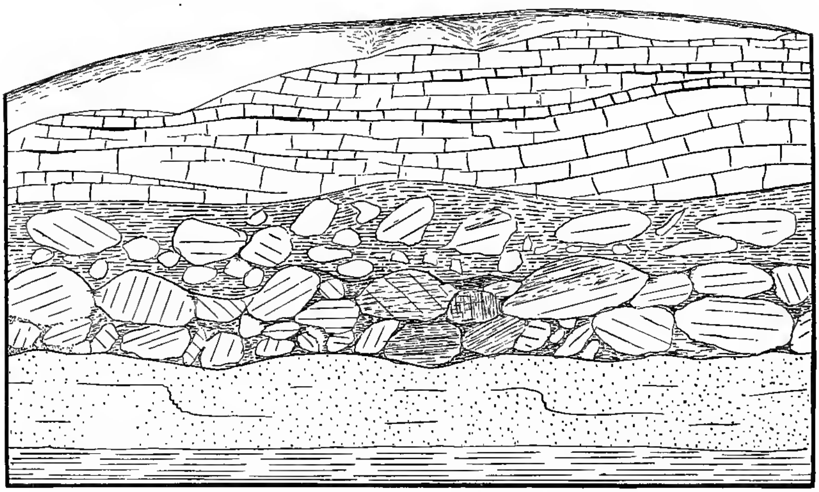


Fig. 3. Base of Saint Louis Limestone at Keokuk

stone. This inference is directly derivable from the faunal and stratigraphical features, and in a less marked degree from the lithological nature of the deposits. The layers passing under this name reported from other localities are now known to have various relationships with the overlying and underlying strata. Alleged faunal peculiarities have usually been the chief grounds for considering the Warsaw as a distinct subdivision of the Lower Carboniferous. Most writers on the subject have united the beds under discussion with the Saint Louis; a few with the Keokuk. This difference of opinion

has arisen largely from the assumptions made at the place most thoroughly studied by the respective authors, without due allowance being made for the varying conditions in distant localities. A careful comparison of notes and a somewhat extended study in the field show that the term "Warsaw" has been very loosely applied since its original appearance as a geological name. In the majority of places the so-called Warsaw is clearly the lower part of the Saint Louis limestone. Thus the writers above alluded to were perfectly correct in contending that the "Warsaw," as they understood it, was really a portion of that formation; but it was a mistake to claim this for the "Warsaw" of all localities. It is apparent, then, that in some places the so-called Warsaw cannot be separated from the Saint Louis limestone; in others it is best united with the Keokuk. It seems best, therefore, to drop the term in its application to a distinct section of the Lower Carboniferous, or Mississippian series, with a rank equal to the other subdivisions here recognized.

SAINT LOUIS LIMESTONE.

Since first recognized by Shumard, little difficulty has been encountered in locating the Saint Louis limestone over a wide stretch of country. Its northern border is several hundred miles beyond any known exposure of Keokuk rocks. From this limit nearly to the Missouri river the limestone is quite thin; but south of the latter point it rapidly thickens until in Ste. Genevieve county, Missouri, it attains a measurement of more than 300 feet, and still farther southward more than double the thickness known in the state mentioned. The Ste. Genevieve limestone, which Shumard differentiated from the Saint Louis deposits near the mouth of the Aux Vases river a few miles below the old village of Ste. Genevieve, appears to be merely the upper part of the main group of strata; and the fossils contained fully substantiated this view. A characteristic exposure is shown in the accompanying plate viii.

An unconformity of the Saint Louis rocks upon the underlying strata in Iowa and in the adjoining portions of the neigh-

boring states has been claimed by White*, but the recent evidence bearing upon the point is not near so conclusive as would be desired. The differences in thickness of the limestone have been alluded to already. This is due partly to the thinning out of the strata northward, and partly to the subaerial erosion prior to the deposition of the Coal Measures of the region.

Over all the northern area of the Saint Louis a characteristic brecciated rock is observable. But south of the Missouri river evenly bedded limestones are present, with occasional extensive beds of oolite. In places, as at Ste. Genevieve, the oolitic limestones present perfect cross-bedding, such as is

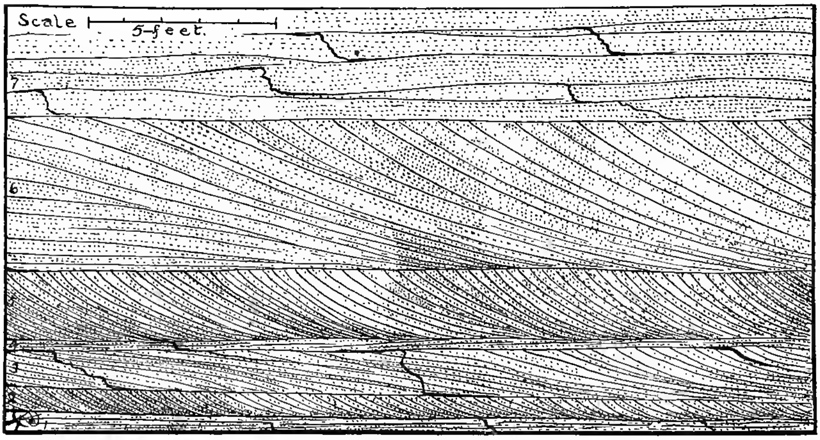


Fig. 4. Cross-bedding of Oolite.

commonly seen in sandstones—a fact which is very suggestive in its bearing upon the origin of certain rocks of this kind.

The faunal features of the Saint Louis are peculiar in many respects, and quite distinct from those of both the overlying and underlying strata, particularly from the latter.

KASKASKIA, OR "CHESTER," BEDS.

Aux Vases Sandstone.—In southern Illinois and southeastern Missouri, the Kaskaskia comprises extensive beds of limestone and shale. Everywhere over this district the calcareous portions, which greatly predominate in the lower part of the

*Geology of Iowa, Vol. I, pp. 225-229. 1870.

SAINT LOUIS LIMESTONE. LORENTZ QUARRY, SAINT LOUIS.

group, are underlain by a fine-grained ferruginous sandrock. This sandstone is said to be recognizable above the city of Saint Louis, where it is a dozen feet or more in thickness. Southward it rapidly thickens, until in the vicinity of the typical locality it attains a maximum measurement of more than 100 feet.

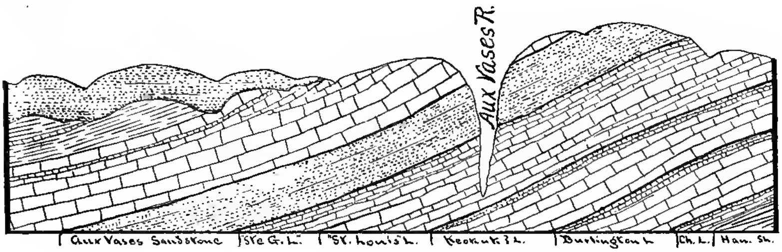


Fig. 5. Aux Vases Sandstone.

The true significance of this great sandstone separating the Saint Louis and Kaskaskia limestones, does not appear heretofore to have been understood fully, especially when taken in connection with the absence of Kaskaskia rocks north of the Missouri river. Over this latter district is an extension of limestone — the St. Louis — which, before the Coal Measures were laid down, was subjected to profound erosion over a large part of its area, and over another adjoining portion, having a great sandstone superimposed. This would seem to indicate that the broad expanse of water which, during the deposition of the Saint Louis beds, reached nearly to the present northern boundaries of Iowa, had retreated more than 400 miles to the southward. Dry land existed over a large part of the area formerly covered by the Saint Louis waters, and bordering this continental mass, arenaceous deposits were laid down in the shallow littoral waters.

In all the Carboniferous of the Mississippi basin, therefore, no group of strata appears to form a better defined natural geological unit than those rocks commonly passing under the name of Kaskaskia or Chester.

The great arenaceous deposit lying at the base of the Kaskaskia limestone has been termed the "ferruginous sandstone" by Shumard and others. Many observers, however, have con-

founded it with a lithologically similar sandrock situated at the base of the Coal Measures, and consequently the latter is located upon, instead of beneath, the Kaskaskia. For convenience in reference, and in order to avoid further confusion, this arenaceous bed will be called the Aux Vases sandstone, from the river of that name in Ste. Genevieve county, where the rock is well exposed. In northern Missouri and Iowa, where the superior member of the Mississippian series is wanting, the basal sandrock of the Coal Measures occupies apparently the same stratigraphical position as the lower Kaskaskia sandstone: that is, directly superimposed upon the Saint Louis limestone.

Kaskaskia Limestone.— The main body of the formation is composed of heavily bedded limestones below, and of plas-

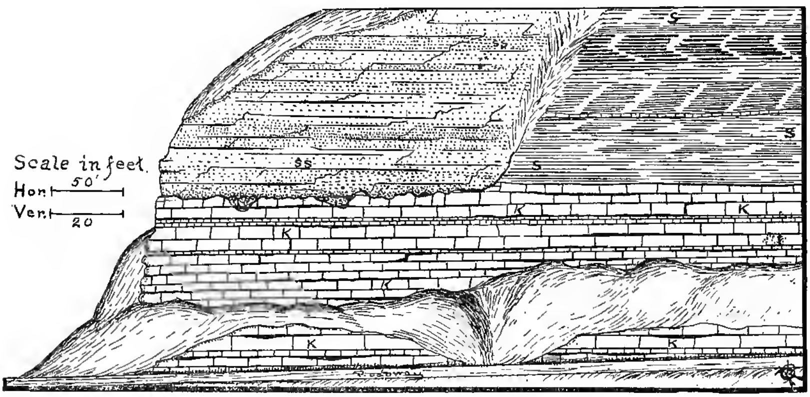


Fig. 6. Sandstone in Gorge of Kaskaskia Beds. Chester.

tic clay-shales with thin calcareous bands above. Everywhere over those portions of the upper Mississippi valley in which the Kaskaskia is absent, the Saint Louis rocks, as already stated, are weathered and deeply channeled, many gorges passing downward even into the Keokuk, thus showing pretty conclusively that these portions of the territory were actually above sea level during a part of the Kaskaskia deposition. That the northern shore line continued to move southward after the Kaskaskia epoch had begun, and perhaps even until the latter half of the interval had set in, is shown by the suc-

cessive attenuations of the several beds and by the deeply excavated ravines, where soon afterward were laid down the local sandstones and shales of the Coal Measures. In a number of cases, at least, these hardened sand accumulations, lying in narrow gorges, have been regarded erroneously as local depositions of Kaskaskia grit, intercalated in the shales and limestone. Furthermore, these consolidated sands contain plant remains, and inasmuch as they have been considered as part of the Kaskaskia, it is quite probable that this will account for some of the reported discoveries of certain terrestrial floras in the rocks of the Mississippian series.

Fig. 7. Details of Juncture of Figure 6.

Faunally, and especially stratigraphically, the Kaskaskia, as displayed everywhere over a broad area adjacent to the line of the Mississippi river, appears separated from the Saint Louis far more widely than any other two members of the entire Lower Carboniferous in the continental interior.

The term "Chester" has been used by some authors for the beds here designated as Kaskaskia. There seems to be, however, but little doubt that the latter name was published several years before Chester made its appearance in print. To be sure, Worthen, while an assistant of Norwood on the geological survey of Illinois, did suggest orally, or in his manuscript notes, as early as 1853, the name of "Chester" for the beds in question, but the name was known for several years only to members of Norwood's corps, as Worthen himself says.* It was at least a dozen years later before the term was published with definite stratigraphical significance, and then with the full knowledge that it covered the same ground as Hall's "Kaskaskia." Hall, as early as 1856, read a paper before the Albany Institute in which he proposed a classification of the Lower Carboniferous of the Mississippi basin, and two years later he published essentially the same scheme in his Iowa report,† accompanied

* Geol. Sur. Illinois, vol. I, p. 41. 1866.
†Geol. Iowa, vol. I, p. 109. 1858.

by a clear description of this formation. Kaskaskia necessarily must be retained, therefore, for the upper member of the Mississippian series in preference to "Chester." If it is desirable to keep the latter term in geological nomenclature, it might be advisable to restrict it to the upper shaly division, which can be advantageously distinguished from the lower massive limestones, and "Chester shales," as they are now often called locally, could still be made a useful term.

The Lower Carboniferous and its Subdivisions.

From the foregoing considerations of the different members of the Lower Carboniferous, or Mississippian, it is to be inferred that upon the best lithological, stratigraphical and faunal evidence now at hand, the series embraces four groups. These, and the various subdivisions that have been recognized from time to time, are tabulated below :

MISSISSIPPIAN SERIES.	Kaskaskia.	"Chester shales." "Kaskaskia limestone." Aux Vases sandstone.
	Saint Louis.	Ste. Genevieve limestone. Saint Louis limestone Warsaw limestone (in part not typical).
	Augusta.	Warsaw shales and limestone (typical). "Geode bed" Keokuk limestone. Upper Burlington limestone. Lower Burlington limestone.
	Kinderhook.	Chouteau limestone. Hannibal shales. Louisiana limestone.

The names given in quotation marks are local applications. The Kaskaskia, aside from the basal sandstone, appears to be a well-defined, two-fold division, and it seems advisable to keep the two members distinct, though special names are not retained for them here. The Saint Louis and Kaskaskia correspond essentially to Williams' "Ste. Genevieve group."

The "Louisiana limestone" is layer number 6 of the Louisiana exposures. The "Hannibal shales" comprise numbers 7 and 8 of the same locality; probably, also numbers 1 and 2 of

the Burlington section. The "Chouteau" is number 9 of the Louisiana locality. The "Lower Burlington limestone" embraces numbers 7 and 8 of the Burlington section; the "Upper Burlington limestone" numbers 9 and 10 of the same. The two together form numbers 10 to 14 inclusive, at Louisiana. The "Keokuk limestone" is numbers 1 and 2 of the Keokuk exposures, number 1 of the Warsaw section, and probably number 1 of the Sainte Genevieve outcrops. The "geode bed" appears as number 3 at Keokuk and number 2 at Warsaw; the typical "Warsaw" embraces numbers 4 to 6 of the Keokuk section and numbers 3 to 5 at Warsaw. The "Saint Louis limestone" is represented by number 7 at Keokuk, number 6 at Warsaw, all of the Saint Louis section, and number 3 at Sainte Genevieve, while number 2 of the same section has been called the Warsaw limestone (not typical). The Sainte Genevieve limestone of Shumard is number 4 of the Sainte Genevieve-Sainte Mary outcrops. The "Aux Vases sandstone" forms bed number 5 between Sainte Genevieve and Sainte Mary, and underlies number 1 of the Chester section a few miles north of the town. The "Kaskaskia limestone" includes numbers 1 to 4 of the Chester section, and the "Chester shales" numbers 5 to 7 of the same section. The Coal Measures are represented at Keokuk by number 8, at Sainte Genevieve by number 7, and at Chester by number 8.

The great abundance of fossils in all the members of the Mississippian series of the interior basin makes the faunal test perhaps the most important of all, in attempting a rational classification of the rocks of the region. Heretofore the remains of ancient life found in these rocks have been considered either from a purely biological point of view, or, as in the majority of cases, from the stand-point of the mere species-maker; and it is only within the past few years that large numbers of species taken together have been compared with one another, in order to marshal the confused hosts into orderly arrangements, so that faunas may be studied as a whole.

The second important consideration to be taken into account in the present connection is the stratigraphical testimony.

In the case of the Kaskaskia the physical breaks are unusually prominent both above and below, over its entire extent in the upper Mississippi valley. What has just been said of the upper member of the series is equally true of the one immediately underlying, though in a less marked degree and over only a part of its superficial extent. Between the lower two groups the physical continuity is scarcely broken, and the separation is chiefly upon faunal and lithological grounds.

Lithologically the upper two members of the Mississippian are more alike than any of the others; yet, as a rule, they are readily distinguishable everywhere. The Augusta limestone is over all its range encrinital, and stands out in marked contrast to the other three sections; while the lower subdivision is very different again, both in its calcareous and argillaceous portions.

In regard to the minor subdivisions of the four groups above mentioned, much might be said. The several sectional names proposed at various times have had wide values, and, moreover, have been applied rather loosely.

In the Kaskaskia the upper shales and the lower limestones of Chester, Illinois, have been differentiated, while the Aux Vases sandstone has been placed at the base of the group provisionally. It has not had, as yet, sufficient study over its entire exposure to satisfactorily consider its relationships in all phases. Certain it is, however, that when the continental area north of the present city of Saint Louis was being subjected to denudation prior to the deposition of the Lower Coal Measures, the great sandstone was laid down south of that point in the shallow littoral waters of the interior sea.

The Saint Louis group has been divided into three limestones. Of these the Ste. Genevieve has never come into general usage, and practically has been forgotten. The Saint Louis limestone proper has been widely recognized, and in many places the lower portions have been correlated with the Warsaw beds as developed at the mouth of the Des Moines river.

The Augusta group is now made to include all five of the hitherto recognized beds—the Warsaw proper, the "geode"

layer, the Keokuk and the upper and lower Burlington limestones.

The Kinderhook group is a three-fold division whose several members are strongly contrasted and persistent over wide areas.

Upper Carboniferous Series or Coal Measures.

The Coal Measures of the upper Mississippi region rest in marked unconformity upon the strata beneath. Within most of the district the rocks immediately below are portions of the Lower Carboniferous, but sometimes older formations come in, Devonian or even Silurian. The surface upon which the coal-

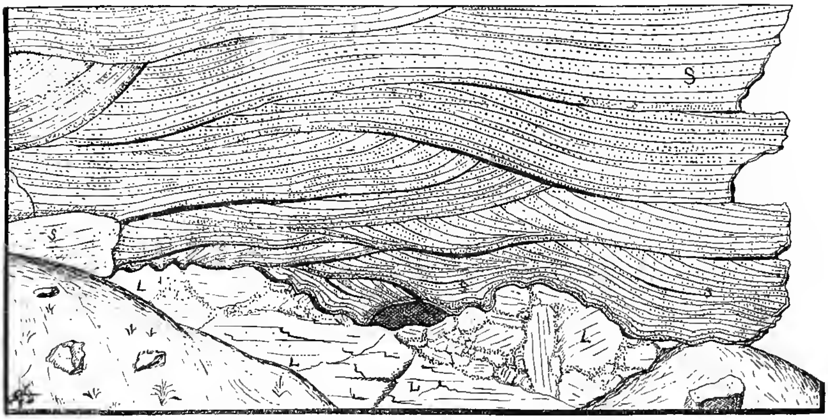


Fig. 8. Coal Measure Sandstone Resting on Saint Louis Limestone. Keokuk.

bearing strata is laid down is everywhere uneven, the irregularities being of such a nature as to leave but little doubt that it is an old land surface. The character of this old erosion plane is shown in the accompanying figure (8), and also in plate ix.

Over the greater part of the Carboniferous area of the Mississippi basin, the Coal Measures are capable of being separated into two portions—one, which forms a marginal zone and is commonly called the lower division, and the other, deposited in more open water, termed the upper section. The two formations are usually tolerably well contrasted in a general way,

though the exact line of separation is not always clearly distinguishable.

In Missouri, however, it has been customary to regard the Coal Measures as made up of three distinct members: Lower, Middle and Upper. These three divisions, though repeatedly described in this and the adjoining states, have never been clearly contrasted, while in the field all tests for distinguishing sharply the several divisions utterly fail. Furthermore the similarly named subdivisions of one state do not at all correspond with those of a neighboring district.

The early impression of this fact in the recent consideration of the coal-field lying to the north of Missouri, quickly led to the query whether the triple subdivision of the series was in reality a natural one. As investigation progressed, it was soon found that the commonly conceived notion of the classification of the Coal Measures was erroneous; that any proposal for such an arrangement must necessarily rest upon a highly artificial basis, with no practical value in applying it to the Mississippi valley region.

In seeking for criteria upon which to establish a natural systematic arrangement of the deposits belonging to the Upper Carboniferous, it was at once discovered that a reconstruction of the original conditions of deposition would aid very materially in the solution of the problem. It had long been a noteworthy fact that the most productive coal deposits in both Iowa and Missouri were situated along the eastern border of the Carboniferous area, and that the western part of the area was occupied chiefly by limestones and calcareous shales. Detailed cross-sections of the geological formations, carefully constructed, showed that the coal-field of the two states mentioned formed a part of what was originally a broad, shallow bay opening to the westward into the great sea which then occupied the greater part of the continent.

In considering, then, the Coal Measures as a whole, two tolerably distinct classes of sediments were readily recognized: (1) the marginal or coastal deposits, and (2) the beds laid down in the more open sea.

JUNCTURE OF COAL MEASURES AND SAINT LOUIS LIMESTONE.

These two categories are sharply contrasted lithologically, stratigraphically and faunally. The first is characterized by the rocks being predominantly clay-shales and sandstones, with practically no limestones. The individual beds have usually a very limited extent, and replace one another in rapid succession, both laterally and vertically. The sandstones often form great lenticular masses, sometimes deeply channeled on the upper surface, the excavations being filled with Coal Measure clays. These and many other phenomena attest a constantly shifting shore line and shallow waters. The fossils contained are nearly all brackish water forms or shore species. Remains of pelagic organisms are not numerous.

On the other hand, the second class of deposits is made up largely of calcareous shales, with heavy beds of limestone. The layers are evenly bedded, and extend over very considerable distances. The faunas are chiefly composed of strictly open-sea forms.

As the conditions of deposition were evidently those of a slowly sinking shore, the marginal deposits as a whole practically underlie the open-sea formations, the former being regarded as the Lower Coal Measures and the latter as the Upper Coal Measures. At the same time it must be remembered that this does not necessarily imply that the "lower" measures are to be considered much older than the "upper," but rather that along the great and successive planes of sedimentation different beds of the upper and lower divisions were laid down contemporaneously.

While the general divisions of the Coal Measures may be readily recognized, it does not seem advisable to draw over the whole region an exact line of demarkation between the two formations, until the evidence of the faunal studies already begun has been fully taken into consideration and a comparison of the results of the different methods of solving the problem is made.

With this idea of the Coal Measures of the interior basin, the limits of the two formations in Missouri, Iowa and the dis-

tricts to the south assume somewhat different lines from those which have been commonly recognized.

The geological cross-sections recently made in central Iowa show clearly that the great limestone of Winterset may be regarded as the base of the "upper" Coal Measures. Coastal sediments carrying workable seams continue up to this line. Above it, open-sea deposits abruptly replace the former, and the coal veins are wanting almost entirely. The great Winterset limestone is known to extend a considerable distance northwestward from its typical locality, probably soon passing beneath the Cretaceous. It has been traced to the south nearly to the south boundary line of Iowa. In Missouri it appears to be continued by what is known as the Bethany Falls limestone, which sweeps southward and westward in a broad arc, and seems to be represented at Kansas City by one of the leading beds exposed in the bluffs at that place.

It is proposed, therefore, to divide the "upper" Carboniferous series, or Coal Measures, into:

(2) The Missouri formation, and

(1) The Des Moines formation.

The Des Moines represents the lower Coal Measures, or the marginal deposits of the upper Carboniferous. It takes its name from the Des Moines river, which flows for more than 200 miles directly through the beds of this terrane. It extends into Missouri and follows the northern and western boundaries of the Ozark uplift into Kansas and Indian territory.

The Missouri corresponds essentially with the "upper" Coal Measures, representing the more strictly marine beds. It is the formation typically developed in the northwestern part of the State of Missouri. The Missouri river also winds its way for more than 400 miles through the beds of this stage, exposing numberless fine sections on both sides of the stream throughout the entire distance.

In lithological characters the Lower Coal Measures are contrasted rather sharply with the great underlying limestone basement, on account of being chiefly argillaceous and arenaceous sediments. No less striking is the relative thickness of

the individual layers which follow and replace one another upward and laterally in rapid succession. Often within a vertical distance of a few inches or a few feet, layers of sand, clay or shale are succeeded by different strata, or else are changed both in color and chemical composition.

The rocks of the upper Carboniferous are principally shales, clays, sandstone, limestone and coal. Of these the clay-shales greatly predominate. The latter are often bituminous, calcareous or arenaceous, and as a matter of course pass gradually in places into sandstone, limestone and coal. On exposure to the atmosphere they quickly disintegrate into soft plastic clays, easily carried away by running water. For the most part they are ashen, dark or black in color, though red, yellow, buff and blue shades are not of uncommon occurrence. In many localities variegated shales prevail—blue, red, yellow and ashen indiscriminately mingled.

The light-colored shales occasionally afford impressions of ferns and lepidodendron roots, but as a rule they are not very fossiliferous. The dark-colored bituminous varieties, on the other hand, are frequently highly charged with organic remains.

The first of these shales, by the gradual addition of fine sandy material, pass imperceptibly into sandy shales, and these again into shaly sandstones, and finally into hard, compact sandrock. This gradual transition may take place laterally in the same horizon, or vertically from one layer to another. By a constant increase of carbonaceous matter, the dark-colored shales become highly bituminous and then coaly.

There is a large amount of sandy material present in the Coal Measures of the State, but it is usually mixed with clay to such an extent as actually to form sandy shales. In some cases, however, the sand constitutes a rock sufficiently compact to afford material for ordinary rough masonry. The sandstone is usually light-colored and more or less friable. In the direction of the seaward dip the sandstones commonly pass by nearly imperceptible degrees into sandy shales and finally into clay shales—the individual layers becoming rapidly thinner and thinner, usually as the proportions of clay increase. The beds

made up of the coarse sand are much thicker than the other layers of similar composition, but they become attenuated in all directions from the center, much more rapidly than the finer and clay-bearing portions.

In the Lower Coal Measures, the limestones play a very unimportant part. They consist merely of a few thin bands, which, however, are the most persistent and easily recognizable over wide areas of any part of the separate horizons. They are usually fragmentary or nodular, very impure from a large admixture of clayey material, and often more or less highly fossiliferous. In the Upper Coal Measures the limerocks become important members. (Plate x.) Being largely open-sea deposits, they have a wide geographical extent. The strata are more compact, more heavily bedded and much thicker than in the lower division. Abundant fossils are enclosed in these rocks, especially where they begin to pass into marly clays. Here they are usually in an excellent state of preservation.

Economically, the coals form by far the most important deposits of the Carboniferous. Stratigraphically, they are of small import. The seams vary from a few inches to several feet in thickness. They are not disposed in a few continuous layers over the entire area, but in numerous lenticular masses, from a few hundred yards to several miles in diameter. A single horizon may thus contain several or many of these lens-shaped beds of greater or less extent. Recognizing this fact, the aggregated amount of coal is probably far in excess of what has been hitherto commonly supposed.

The general stratigraphical features of the Missouri Coal Measures have been so clearly set forth lately,* that some of the leading suggestions may be summarized in the present connection.

The Coal Measure rocks of Missouri are arranged in a series of strata which have generally a slight, undulating westerly dip, such as the uppermost rocks are at the surface in the

* Winslow: Geol. Sur. Missouri, Prelim. Rep. Coal, pp. 22-32.

COAL MEASURES AT KANSAS CITY.

northwestern portion of the state, and the lower rock crops out along the margin to the east.

The estimated maximum thickness of these Coal Measure rocks is about 2000 feet. That is, to penetrate the entire section of these strata at a point in the northwestern corner of the state, a shaft 1900 feet deep would be necessary. Eastward from such a point the thickness of the underlying rocks constantly diminishes, owing partly to the westward tilting of the strata above referred to, and partly to the conditions under which these strata were deposited, which is elsewhere discussed. Therefore, the thickness of this formation at any point within the area of its distribution may be anywhere from 0 to 1900 feet.

Thus, along the margin, the Coal Measure formation may be considered to taper to a feather edge, while in the extreme northwestern corner of the state it has an aggregate thickness of nearly 2000 feet, and consists of more than 200 strata.

On the basis of the figures recently given, there is an elevation of about 200 feet for the floor of the Coal Measures at the margin near Sedalia, and in the extreme northwest the elevation of the floor is about minus 700 feet; the consequent present slope of this floor is 1600 feet in a distance of some 150 miles, which is equivalent to about 10 feet per mile, or about one-tenth of one degree, which is almost horizontal. The elevation of the surface of Maryville is about 1200 feet, so that the thickness of the Coal Measures there, above the level of Sedalia, is only 300 feet.

Among the most noticeable features of the stratigraphy of these Coal Measures is the variability of details. Strata are characteristically non-persistent, both as regards thickness, as well as material.

According to views usually presented, the Coal Measures of Missouri have been separated into an upper, middle and lower division, respectively 1317, 324 and 250 feet thick,* all having a slight dip a little north of west. The common conception regarding these divisions is that they underlie each

* Missouri Geol. Sur. part I, p. 6, 1872.

other successively, and that should the strata of the upper Coal Measures in the northwestern part of the state be penetrated by a shaft, the members of the middle and lower Coal Measures would be successively encountered. The reservation is generally made, however, that some of the beds will probably thin out, disappear, or be replaced by others, so that exactly the same succession of strata cannot be expected, though whatever may be included under the indefinitely applied term "formation"* is considered to be continuous.

Recalling the remarks already made concerning the Lower Carboniferous, it will be remembered that there was abundant evidence for believing that over the region of the Upper Mississippi basin the Saint Louis seas extended northward nearly to the present Iowa-Minnesota line; that at the beginning of the Kaskaskia epoch a considerable elevation of the land took place, pushing the shore line several hundreds of miles to the south, even as far as the site of the present city of Saint Louis. During this time there was considerable subaerial erosion over all the Iowa and northern Missouri areas—shore deposits being laid down along the line of the Mississippi river in southeastern Missouri and southwestern Illinois, and open-sea deposits farther southward, and probably also west of the Missouri river.

A new period of subsidence setting in closed the Lower Carboniferous in this part of the American continent. On the south, with the Ozark uplift probably above the sea-level, and connected or separated only by narrow, shallow straits with the land around the present mouth of the Missouri, and on the east and north with a rise of moderate elevation, the broad basin-shaped lowland, inclined westward toward the open sea, was especially well adapted for the formation and preservation of coal deposits, as the depression continued and the waters of the sea gradually encroached upon the land. In many places the bottom of the broad basin being kept not far from sea-level, slight oscillations allowed the land surface to appear and thus change the local conditions of deposition. The con-

Geol. Sur. Missouri, Prelim. Rep. Coal. Jefferson City, 1892.

stantly moving marginal zone, creeping inland, overlapped and covered the older rocks, while farther seaward very different deposits were laid down. Thus in the coastal swamps coal and its associated beds were being formed contemporaneously with the clays and limestones farther outward.

In Missouri the Coal Measures have a slight general slope to the northwest or west; in Iowa they dip to the west or southwest. That is, they are now inclined seaward toward the open sea of later Paleozoic times in the continental interior. The region has doubtless undergone many slight oscillations since Paleozoic times, and beds are probably now considerably nearer the line of horizontality than they were when originally deposited, the successive later tillings having left western portions of the area relatively somewhat higher than when the rocks were first formed, yet allowing the original westerly direction of the dip to remain about the same.

CRETACEOUS.

In the bluffs of the Mississippi river, in Scott county, there are certain arenaceous beds often somewhat argillaceous, which, on account of lying beneath the so-called Eocene deposits of the region, have been referred doubtfully to the Cretaceous age. They are said to rest unconformably upon the Silurian strata, and have overlying beds superimposed unconformably upon them. Considerable disturbance in the regularity of the strata is noticeable.

In connection with the probable occurrence of Cretaceous rocks in southeastern Missouri, it is of interest to know that quite recently the strata of the same age have been traced from the north in Iowa nearly to the boundary in Missouri, so that it is not improbable that Cretaceous outliers will eventually be found in the northwestern portion of the state.

EOCENE.

The Mississippi embayment, which in early Tertiary times extended northward beyond the present mouth of the Ohio, appears to have reached into Missouri. The deposits which

are thought to represent the Eocene consist chiefly of brown sands and blue clays, with some iron ores. The best exposures are found in the blnffs of the Mississippi in Scott and Stoddard counties.

PLIESTOCENE.

The drift mantle extends from the northern boundary of the state southward as far as the Missouri river approximately. These deposits consist mainly of silts, sands and boulder clays, incoherent and indiscriminately mixed.

CHAPTER III.

BIOLOGICAL RELATIONS OF FOSSILS.

Proper discrimination between similar fossil forms is very essential to the thorough understanding of the rocks of a locality. For through the means of the ancient forms of life the geological age of the sediments under consideration is inferred.

The importance of adequate representations of the leading fossils in an area exposing the strata to be investigated, either for scientific interest or economical purposes, cannot, therefore, be overestimated.

In glancing over the list of fossils herein recorded, one is impressed at once with the rich and varied character of the faunas found within the limits of the state of Missouri. The upper Paleozoic rocks, especially, are perhaps more prolific in the remains of ancient life than in any other like district within the Mississippi basin. Not only are the species numerous but individuals are exceedingly abundant, locally, as well as throughout the state, wherever those rocks are exposed.

Aside from the practical and geological interest these fossils possess, they offer unusually favorable opportunities for biological studies—the evolution and succession of particular types and groups; and the geographic distribution of species in very ancient times.

It is to be regretted that this phase of the subject could not have been taken up more fully at the present time; but the unusual and unexpectedly large amount of material that had to be examined necessitated the postponement of this treatment to another time. Much valuable information has accumulated for further faunal studies, and this will be incorporated

with observations made in the future, into a suitable statement of the facts as known.

In the consideration of a large assemblage of organic remains, it becomes necessary at the outset to formulate some plan by which ready reference at all times can be made to the various species. In many reports on the paleontology of states or districts, the systematic arrangement of the fossils treated is in accordance with the geological horizons—the oldest coming first and the youngest last. But it is readily seen there are serious objections to this method, aside from its not being adapted to the practical wants of those into whose hands the reports chiefly fall. For these reasons, the plan adopted here is to bring as near together as possible all similar forms in order of their genetic relationships. The classification is essentially, then, a zoological one.

For reasons already stated, a chapter has been devoted to a synopsis of the invertebrate animals generally. In the main it follows Nicholson's tabular view, as given in the recently issued Manual of Paleontology. There are, however, a number of important changes in classification, some abridgments, and a few additions.

The groups unrepresented in Missouri, so far as is known at least, and those which are not preserved as fossils, are marked with an asterisk. With many of these, though large groups, the subordinate divisions are omitted entirely. In the case of the others, or those found within the limits of the state, the majority or all of the minor subdivisions are given, in order to facilitate any comparisons that may be instituted. Many of the representative genera are also appended to each family. For further details, reference to the subsequent chapters must be made.

SYNOPTICAL TABLE OF THE LEADING DIVISIONS OF THE ANIMAL KINGDOM.

Subkingdom I.—PROTOZOA.

Class I.—**Gregarinida.***

Class II.—**Rhizopoda.**

(1) MONERA.*
(2) AMŒBA.*
(3) FORAMINIFERA. Numulitidæ—*Fusulina.*
(4) RADIOLARIA.*
(5) HELIOZOA.*

Class III.—**Infusoria.***

Subkingdom II.—PORIFERA.

Class I.—**Plethospongiæ.**

(1) MYXOSPONGIÆ.*
(2) CERATOSPONGIÆ.*
(3) MONACTINELLIDÆ.*
(4) TETRACTINELLIDÆ.*
(5) LITHISTIDÆ.*
(6) HEXACTINELLIDÆ. Receptaculitidæ—*Receptaculites.*
(7) OCTACTINELLIDÆ.*
(8) HETERACTINELLIDÆ.*

Class II.—**Calcispongiæ.***

Subkingdom III.—CŒLENTERATA.

Class I.—**Hydrozoa.**

(1) HYDROIDEA.*
(2) SIPHONOPHORA.*
(3) LUCERNARIDA.*
(4) GRAPTOLITOIDEA.*
(5) HYDROCORALLINÆ.*
6) STROMATOPORIDEA. Stromatoporidæ—*Stromatopora.*

Class II.—**Actinozoa.**

(1) ALCYONARIA. Pennatulidæ.*
Gorgonidæ.*
Tubiporidæ—
Syringopora, Halysites, Aulopora.
Helioporidæ.*

(2) ZOANTHARIA. Cyathophyllidæ—
Cyathophyllum, Lithostrotion.
Heliophyllidæ—*Phillipsastrea.*
Cliotophyllidæ—*Axophyllum.*
Zaphrentidæ—
Amplexus, Zaphrentis, Lophophyllum.
Streptalasmidæ—*Streptalasma.*
Cystophyllidæ—*Cystophyllum.*
Calciolidæ.*
Poritidæ—
Favosites, Palæacis, Striatopora.
Madreporidæ.*
Pocilloporidæ.*
Eupsammidæ.*
Fungidæ.*
Astræidæ.*
Stylophoridæ.*
Oculinidæ.*
Dasmidæ.*
Turbinolidæ.*

(3) MONTICULIPOROIDEA. Monticuliporidæ.
Fistuliporidæ—*Fistulipora.*

(4) CTENOPHORA.*

Subkingdom IV.—ECHINODERMATA.

Class I.—**Holothuroidea.***

Class II.—**Ophiuroidea.**

(1) EURYALIDA. Euryalidæ—*Onychaster.*

(2) OPHIURIDA.*

Class III.—**Asteroidea.***

Class IV.—**Echinoidea.**

(1) PALÆCHINOIDEA. Cystocidaridæ.*
Bothriocidaridæ.*
Lepidocentridæ.*
Melonitidæ—*Melonites, Oligoporus.*
Archæocidaridæ—*Archæocidaris.*
(2) EUECHINOIDEA.*

Class V.—**Cystoidea.**

(1) APORITIDA. Agelacrinidæ—*Echinodiscus.*
(2) DIPLOPORIDA.*
(3) RHOMBIFERI. Camarocystitidæ—*Camarocystites.*

Class VI.—**Blastoidea.**

(1) REGULARES. Pentremitidæ—*Pentremites.*
Troostoblastidæ—*Metablastus.*
Nucleoblastidæ—
Elæocrinus Schizoblastus, Cryptoblastus.
Granatoblastidæ—*Granatocrinus.*
Codasteridæ—*Codaster, Orophocrinus.*
(2) IRREGLARES.*

Class VII.—**Crinoidea.**

(1) COADUNATA. Reteocrinidæ.*
Rhodocrinidæ—*Rhodocrinus, Gilbertsocrinus.*
Glyptasteridæ.—*Ptychocrinus.*
Melocrinidæ.—*Glyptocrinus.*
Actinocrinidæ.—
Actinocrinus Megistocrinus, Dorycrinus.
Platycrinidæ.—*Eucladocrinus, Platycrinus.*
Hexacrinidæ.—*Dichocrinus, Talarocrinus.*
Acrocrinidæ.*
Barrandeocrinidæ.*
Calyptocrinidæ.*
Crotalocrinidæ.*

(2) INADUNATA. Haplocrinidæ*
Symbathocrinidæ.—*Symbathocrinus.*
Cupressocrinidæ.*
Gasterocomidæ.*
Hybocrinidæ.*
Heterocrinidæ.*
Anomalocrinidæ.*
Belemnocrinidæ.—*Belemnocrinus.*
Cyathocrinidæ.—
Cyathocrinus, *Barycrinus*, *Lecythiocrinus.*
Poteriocrinidæ.—*Poteriocrinus*, *Zeacrinus*, *Eupachycrinus*, *Phialocrinus*, *Cromyocrinus.*
Encrinidæ.*
Astylocrinidæ.—
Agassizocrinus, *Edriocrinus.*
Catillocrinidæ.*
Calceocrinidæ.—*Calceocrinus.*

(3) ARTICULATA. Icthyocrinidæ.—*Icthyocrinus*, *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus.*
Uintacrinidæ.*

(4) CANALICULATA. Pentacrinidæ.*
Comatulidæ.*
Bourgueticrinidæ.*
Eugeniacrinidæ.*
Holopidæ.*
Plicatocrinidæ.*
Apiocrinidæ.*
Marsupitidæ.*
Saccocomidæ.*

Subkingdom V.—VERMES.

Class I.—**Platyhelmia.***

Class II.—**Nemathelmia.***

Class III.—**Rotifera.***

Class IV.—**Gephyra.***

Class V.—**Myzostomida.***

Class VI.—**Annelida.***

Class VII.—**Chætonatha.***

Subkingdom VI.—ARTHROPODA.

Class I.—**Crustacea.**

(1) CIRRIPEDIA.*
(2) RHIZOCEPHALA.*
(3) OSTRACODA. Leperditidæ—*Beyrichia.*
Cypridinidæ.*
Polycopidæ.*
Cytherellidæ *
Cytheridæ—*Cythere.*
Cypridæ.*
(4) COPEPODA.*
(5) CLADOCERA.*
(6) PHYLLOPODA.*
(7) PHYLLOCARIDA.*
(8) TRILOBITA. Harpedidæ.*
Remopleuridæ.*
Olenidæ.*
Conocephalidæ.*
Bohemillidæ.*
Calymenidæ— *Calymene.*
Asaphidæ—*Asaphus.*
Illænidæ—*Illænus.*
Æglinidæ.*
Cheiruridæ.*
Encrinuridæ—*Encrinurus.*
Dindyminidæ.*
Acidaspidæ—*Acidaspis.*
Lichadæ—*Lichas.*
Bronteidæ.*

Phacopidæ—*Phacops, Dalmanites.*
Proetidæ.—*Cyphaspis, Proetus, Phillipsia.*
Agnostidæ.*
Trinucleidæ.*

(9) XIPHOSURA.*
(10) EURIPTERIDA.*
(11) AMPHIPODA.*
(12) ISOPODA.*
(13) STOMAPODA.*
(14) SCHIZOPODA.*
(15) CUMACEA.*
(16) DECAPODA.

Class II.—**Arachnida.***

Class III.—**Myriapoda.***

Class IV.—**Insecta.***

Subkingdom VII.—MOLLUSCA.

Class I.—**Bryozoa.**

(1) PHYLACTOLÆMATA.*
(2) GYMNOLŒMATA. Crisiidæ.*
Diastoporidæ.*
Tubuliporidæ.*
Entalophoridæ.*
Idmonidæ.*
Lichenoporidæ,*
Frondiporidæ.*
Heteroporidæ.*
Fenestellidæ—
Fenestella, Archimedes, Lyropora.
Acanthocladidæ—*Setopora.*
Ptilodictyonidæ—*Stictoporella.*
Strictoporidæ.*
Cystodictyonidæ.*
Ceramoporidæ.*
Rhabdomesonidæ.—*Rhombopora.*
Catenicellidæ.*

Salicornadæ.*
Cellularidæ.*
Gemellaridæ.*
Hippothoidæ.*
Membraniporidæ.*
Escharidæ.*
Steginoporidæ.
Celliporidæ.
Vincularidæ.
Selenariidæ.

Class II.—Brachiopoda.

(1) PLEUROPYGIA. Lingulidæ—*Lingula, Lingulella.*
Obolidæ.*
Discinidæ—*Discina.*
Trimerellidæ.*
Craniadæ—*Crania.*

(2) APYGIA. Productidæ—*Productus, Chonetes, Productella.*
Strophomenidæ—*Orthis, Meekella, Streptorhynchus.*
Koninckinidæ—*Strophomena, Leptæna, Syntrelasma.*
Spiriferidæ—*Spirifera, Syringothyris, Cyrtina, Athyris.*
Atrypidæ—*Atrypa, Tygorpira.*
Rhynchonellidæ—*Rhynchonella.*
Stringocephalidæ.
Thecideidæ.*
Terebratulidæ—*Terebratula.*

Class III. Lamellibranchiata.

(1) OSTRACEA.*

(2) PECTINACEA. Spondylidæ.*
Limidæ—*Lima.*
Pectenidæ—*Aviculopecten, Entolium.*

(3)	MYTILACEA.	Aviculidæ—*Avicula*, *Ambonychia*, *Myalina*.
		Mytilidæ—*Modiola*.
		Pinnidæ—*Pinna*.
(4)	ARCACEA.	Arcidæ—*Macrodon*.
		Nuculidæ—*Nucula*, *Leda*.
(5)	SUBMYTILACEA.	Modiolopsidæ.
		Trigoniidæ.
		Unionidæ.*
		Cardiniidæ.*
		Carditidæ—*Pleurophorus*.
		Astartidæ—*Astartella*.
		Crassatellidæ.*
(6)	ERYCINACEA.*	
(7)	CARDIACEA.	Cardiidæ—*Conocardium*.
		Tridacnidæ.*
(8)	CHAMACEA.	Chamidæ.*
		Rudistæ.*
(9)	CONCHACEA.	Megalodontidæ.*
		Cyrenidæ.*
		Cyprinidæ.—*Cypricardia*.
		Veneridæ.*
		Donacidæ.*
		Ungrelinidæ.*
		Unicaridæ.*
		Tancrediidæ.*
		Solenidæ.
(10)	MYACEA.	Mactridæ.*
		Myidæ.*
		Gastrochænidæ.*
		Glycimeridæ.*
(11)	ADESMACEA.	Pholadidæ.*
		Teretinidæ.*
(12)	LUCINACEA.	Lucinidæ.
(13)	TELLINACEA.	Tellinidæ.*
		Scrobicularidæ.*
(14)	ANATINACEA.	Solemyidæ.—*Clinospistha*.
		Anatinidæ.—*Allorisma*.

Grammysiidæ.—*Leptodomus,Edmondia, Sanquinolites.*
Præcardiidæ.*
Pholadomyidæ.*

Class IV.—Gasteropoda.

(1) PROSOBRANCHIATA. Patellidæ.*
Fissurellidæ.*
Haliotidæ.*
Capulidæ.—*Capulus.*
Velutinidæ.*
Pleurotomaridæ. — *Pleurotomaria, Rhaphistoma, Murchisonia.*
Bellerophontidæ.—*Bellerophon, Bucania, Porcellia, Cyrtolites.*
Stomatiidæ.*
Euomphalidæ.—*Euomphalus, Straparollus, Ophileta, Maclurea.*
Trochidæ.*
Solaridæ.*
Turbinidæ.—*Cyclonema.*
Xenophoridæ.*
Neritidæ.*
Helicinidæ.*
Naticidæ—*Naticopsis, Strophostylus.*
Paludinidæ.*
Rissoidæ.*
Littorinidæ—*Holopea.*
Scalariidæ
Ianthinidæ.*
Turritellidæ.*
Vermetidæ.*
Cæcidæ.*
Pyramidellidæ.*
Pseudomelanidæ—*Loxonema, Soleniscus.*
Subulitidæ.

(2) OPISTHOBRANCHIATA.*
(3) HETEROPODA.*
(4) PTEROPODA. Conulariidæ—*Conularia.*
Tentaculitidæ—*Tentaculites.*
(5) STYLOMMATOPHORA.*
(6) BASOMMATOPHORA.*

Class V.—Polyplacophora.*

Class VI.—Scaphora.

(1) SOLENOCONCHIA. Dentaludæ—*Dentalium.*

Class VII.—Cephalopoda.

(1) TETRABRANCHIATA. Orthoceratidæ—*Orthoceras.*
Ascoceratidæ.
Cyrtoceratidæ—*Cyrtoceras.*
Nautilidæ—*Nautilus.*
Trochoceratidæ.
Clymenidæ.
Goniatitidæ—*Goniatites.*
Arcestidæ.
Tropitidæ.
Ceratitidæ.
Cladiscitidæ.
Pinasocenatidæ.
Phylloceratidæ.
Lytoceratidæ.*
Ptychitidæ.*
Amaltheidæ.*
Aegoceratidæ.*
Harpoceratidæ.*
Haploceratidæ *
Stephanoceratidæ.*
Phragmophora.*
Seprophora.*
Chondrophora.*

Class VIII.—Tunicata.

Subkingdom VIII.—VERTEBRATA.

Class I.—**Leptocardia.***

Class II.—**Pisces.**

Class III.—**Amphibia.***

Class IV.—**Reptilia.***

Class V.—**Aves.***

Class VI.—**Mammalia.***

CHAPTER IV.

PROTOZOANS AND SPONGES.

Fusulina cylindrica FISCHER.

Plate xii, figs. 1*a-c*.

Fusulina cylindrica Fischer, 1837: Orcyst. du Gouv. de Moscau, p. 126, pl. xviii, figs. 1-5.

Fusulina cylindrica Owen, 1852: Geol. Sur. Iowa, Wisconsin and Minnesota, p. 130.

Fusulina cylindrica Meek and Hayden, 1864: Pal. Upper Missouri, p. 14, pl. i, figs. 6*a-c*.

Fusulina cylindrica Geinitz, 1866: Carb. und Dyas in Nebraska, p. 71, tab. v, fig. 5.

Fusulina cylindrica Meek, 1872: U S. Geol. Sur. Nebraska, p. 140, pl. i, fig. 2; pl. ii, fig. 1; pl. v, figs. 3*a-b*; pl. vii, figs. 8*a-b*.

Fusulina cylindrica White, 1877: U S. Geol. Sur. W. 100 Merid., vol. IV, p. 96, pl. vi, figs. 6*a-b*.

Fusulina cylindrica Keyes, 1891: Proc. Acad. Nat. Sci., Phila., p. 245.

Rather small, seldom exceeding six millimeters in length of axis, fusiform, more or less ventricose medially, and blunt at the ends, which are often slightly twisted. Surface marked by rather distinct septal furrows. Aperture very narrow. Volutions seven to eight, closely coiled. Septa from twenty to thirty or more in number in the last whorl. Foramina quite distinct in well-preserved specimens.

Horizon and Localities.—Upper Carboniferous, Coal Measures: Kansas City, Lexington.

This species is very widely distributed both in time and space and as a matter of consequence it presents, as might be expected, many varietal phases. There is, therefore, apparently very good grounds, as suggested by White, for regarding the various forms described as *Fusulina depressa, F. ventricosa, F. robusta, F. gracilis,* etc., as identical with *F. cylindrica*, the slight differences being due to local variations of environment rather than specific modifications in structure.

Receptaculites oweni Hall.

Plate xii, figs. 2*a*-*b*.

Cosinopora sulcata Owen, 1844: Geol. Expl. Iowa, Wisconsin and Illinois, p. 40, pl. vii, fig. 5. (Not Goldfuss.)

Receptaculites oweni Hall, 1851: Geol. Sur. Wisconsin, Rept. Prog., p. 13.

Receptaculites oweni Hall, 1862: Geol. Sur. Wisconsin, p. 46, fig. 3.

Receptaculites oweni Meek and Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 302, pl. ii, fig. 3.

Receptaculites oweni Whitfield, 1882: Geol. Sur. Wisconsin, vol. IV, p. 239, pl. x, fig. 7.

Very large, forming broad, discoidal expansions, from two or three to twenty or more inches in diameter; very thin centrally, but greatly thickened toward the margins. "The substance of the fossil is filled with circular, cell-like perforations, placed perpendicular to the plane of the disk, and arranged in curved or concentric lines or rows, which radiate or diverge from a central point, and the cells gradually increase in dimensions as they approach the margin of the disc; but with frequent intercalated rows. The cells are arranged so as to form circular and often direct radiating lines, as well as the concentrically curved lines above mentioned. Cell apertures on the lower side, nearly as large as the body of the cell within, with the margins excavated or flaring, forming sharply angular surfaces on the partition walls; but on the upper surface they are contracted to about half the diameter of the tube within, and the aperture is rhombic or quadrangular, with walls, which are variously ornamented according to the condition of preservation and the compactness of the arrangment." (Whitfield.)

Horizon and Localities.—Lower Silurian, Trenton limestone: Jefferson, Pike and Saint Louis counties.

CHAPTER V.

HYDRAZOIDS AND CORALS.

Stromatopora expansa Hall and Whitfield.

Stromatopora expansa Hall and Whitfield, 1873: New York State Cab. Nat. Hist., 23rd Rept., p. 226, pl. ix, fig. 1.

Growths irregular, somewhat spheroidal, made up of numerous thin, closely arranged concentric shells, which have a well defined fibrous structure and are perforated by minute pores.

Horizon and Localities.—Devonian, Callaway limestone: Winfield (Lincoln county).

None of the species thus far found preserve the minute structure sufficiently well for satisfactory microscopic examination. The zoological affinities of the group are little understood as yet, while the objects referred to the genus have comprised a heterogeneous mixture—poorly preserved fossils, having no relation whatever to this group, or even concretionary structures.

Acervularia davidsoni Edwards & Haime.

Acervularia davidsoni Edwards & Haime, 1851: Monog. des Polyp. Foss. d. Terr. Palæ., p. 318, pl. ix, figs. 4–43.

Acervularia davidsoni Hall, 1858: Geology Iowa, vol. I, p. 476, pl. 1, figs. 8*a–b*.

Acervularia davidsoni Nicholson, 1875: Geol. Sur. Ohio, vol. II, p. 240.

Cyathophyllum davidsoni Rominger, 1876: Geol. Sur. Michigan, vol. III, p. 107, pl. xxxvii, fig. 4.

Corallum large, lenticular, composed of polygonal corallites, which are seldom of the same size; lower surface covered by a rather thick, wrinkled, epithecal crust. Corallites with the walls more or less distinctly zigzag in cross-section; the interior wall not well defined. Septa about 40 in number, with serrated margins.

Horizon and locality.—Devonian, Hamilton limestone: St. Louis county.

The American corals of this group appear properly to belong under Cyathophyllum, as has already been announced by Rominger. The internal wall, which is said to be so characteristic of Acervularia, is rarely, if ever, well defined, in the forms under consideration. The nearest approach to the annular wall appears to be the enlargement of some of the smaller lamellæ along the inner margins. But in no case have these thickenings been observed, in connection with the alternating larger septæ, to form a closed ring.

In those specimens in which the growth of some of the corallites has been accelerated more than others, the calyces have assumed a circular instead of polygonal shape as in *Cyathophyllum cæspitosum* Goldfuss, and other more typical forms of the genus.

Cyathophyllum cornicula Rominger.

Plate xli, fig. 4.

Cyathophyllum cornicula Rominger, 1876: Geol. Sur. Michigan, vol. III, pt. ii, p. 102, pl. xxxv, fig. 2.

Very similar to *C. glabrum*, which, however, differs from this form in being more slender, in possessing a very deep calyx, in the greater number of lamellæ, and in having the surface smooth, instead of conspicuously annulated.

Horizon and localities.—Devonian, Calaway limestone: Winfield (Lincoln county).

At present, data are not at hand to satisfactorily determine whether or not this form is identical with *Caryophellia cornicula* of Lesueur, or *Zaphrentis cornicula* of Milne-Edwards.

Cyathophyllum glabrum *sp. nov.*

Plate xii, figs. 6a-b.

Corallum simple, turbinate, moderately curved, annulated by broad folds; base attenuated. Calyx very deep, lamellæ numerous, 80 to 100 in number; interlamellar spaces occupied by transverse plates, but leaving the inner margin of the vertical septæ free, and making the peripheral area quite vesiculose.

Surface marked by numerous fine, annular wrinkles of growth, which pass around on the broad folds as well as the intervening constrictions; vertical striations poorly defined.

Horizon and locality.—Lower Carboniferous, Upper Kinderhook (Chouteau) limestone: Curryville (Pike county).

This species bears considerable resemblance to *C. cornicula* (Ed. & H.) from the Devonian, but it has a more slender form, a very deep calycinal cavity, much more numerous and delicate lamellæ, while the surface is perfectly smooth and is more annulated. There is some doubt as to the correctness of the generic reference of this form, as it possesses many of the characteristics of Campophyllum; especially as the lamellæ are rather short, and do not appear to meet in the center, except, perhaps, in the immediate vicinity of the base. This apparent blending of the structural features found in two different genera is quite suggestive when taken into consideration with the commonly recognized geological range of the corals of this group. True forms of Cyathophyllum are distributed most widely in the Silurian and Devonian; while Campophyllum is most abundant in the later Devonian and the Carboniferous. In America the first of these genera is almost entirely confined to strata earlier than the Carboniferous. The forms of the second group, with a single exception, belong to the later Paleozoic.

Lithostrotion mamillare Castelnau.

Plate xii, fig. 8.

Astrœ mamillaris Castelnau, 1843: Terraine Sil. de l'Amerique du Nord, p. 50, pl. xxiv, fig. 5.

Lithostrotion mamillare Edwards and Haime, 1841: Monog. des Polyp., p. 433, pl. xiii, figs. 1-1b.

Lithostrotion basaltiforme Owen, 1852: Geol. Wisconsin, Iowa and Minnesota, tab. iv, figs. 5 and 6

Lithostrotion mamillare Hall, 1858: Geol. Iowa, vol. I, p. 667, pl. xxiv, figs. 5a-b.

Lithostrotion proliferum Hall, 1858: Geol. Iowa, vol. I, p. 668, pl. xxiv, figs. 6a-c.

Lithostrotion mamillare Rominger, 1876: Geol. Sur. Michigan, vol. III, p. 111, pl. lv, figs. 1-2.

Corallum usually forming large astræiform masses, composed of long polygonal corallites, which increase by budding at the margins of the calycinal disks. Calyces rather deep, obliquely spreading upward to the margins; the central basal portions reflected upward into a rather conspicuous cone. Radical lamellæ from 20 to 40 in number.

Horizon and localities.—Lower Carboniferous, St. Louis limestone: St. Francisville (Clark county), Ste. Genevieve, St. Louis.

Campophyllum torquium (OWEN).

Plate xii, figs. 7a-c, and plate xiii, fig. 7.

Cyathophyllum torquium Owen, 1852: Geol. Sur. Wisconsin, Iowa and Minnesota, tab. iv, fig. 2.

Campophyllum torquium Meek, 1872: U. S. Geol. Sur. Nebraska, p. 145, pl. i, fig. 1.

Campophyllum torquium White, 1884: Geol. Sur. Indiana, 13th Ann. Rept., pt. ii, p. 119, pl. xxiii, figs. 10-13.

Corallum solitary, large, flexuous, more or less wrinkled; calyx circular, deepening abruptly toward the center; septal fossette distinct. Primary lamellæ about 40 in number, reaching from the margin half way to the center; secondary septæ small; tabulæ large, arched; dissepiments numerous.

Horizon and localities.—Upper Carboniferous, Coal Measures: Kansas City.

Axophyllum rude WHITE & ST. JOHN.

Plate xii, figs. 5a-b.

Axophyllum rude White & St. John, 1867: Trans. Chicago Acad. Sci., vol. 1, p. 115.

Axophyllum rude White, 1884: Geol. Sur. Indiana, 13th Ann. Rep., pt. ii, p. 118, pl. xxiii, figs. 8-9.

Axophyllum rude Worthen & Meek, 1875: Geol. Sur. Illinois, vol. VI, p. 525, pl. xxxii, figs. 6-6c.

Corallum simple, broadly obconic, with internal structure much like that of Lithostrotion.

Horizon and localities.—Carboniferous, Upper Coal Measures: Kansas City.

Amplexus yandelli? Edwards & Haime.

Plate xiii, fig. 2.

Amplexus yandelli Edwards & Haime, 1851: Monog. Polyp. Foss. d. Terr. Pal., p. 344.

Amplexus yandelli Rominger, 1876: Geol. Sur. Michigan, vol. III, pt. ii, p. 155, pl. liv, fig. 2.

Conico-cylindrical, flexuose stems, from two to four centimeters in diameter, annulated by fine wrinkles of growth, with intermediate coarser rugæ, and frequently of a jointed structure through periodical constrictions of the calyces and the continued growth of the stem without interruption of the continuity of the epithecal wall. Calyces deep, with erect margins, surrounded by about sixty alternately large and small vertical crests. The bottom of the calyces is formed by flat or warped diaphragms, depressed on one side by deep septal fovea. The lamellæ are restricted to the outer circumference of the diaphragms, but sometimes they extend to the center as superficial ridges. (Rominger.)

Horizon and localities.—Lower Carboniferous, Kinderhook limestone (Chouteau): Curryville (Pike county).

Certain Carboniferous corals from Curryville correspond so perfectly to authentic examples of *A. yandelli* that it is almost impossible to refer them to any other species. They answer so well to Rominger's description of Edwards & Haime's species that it is repeated here.

Amplexus blairi Miller.

Plate xiii, fig. 1.

Amplexus blairi Miller, 1891: Geol. Sur. Indiana, 16th Ann. Rept., Ad. Sheets, p. 8, pl. i, fig. 7.

Similar to *A. fragilis*, but much smaller, more slender, somewhat tortuose, with the diaphragms proportionally much further apart and the lamellæ much more prominent.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Springfield, Sedalia, Louisiana; Burlington (Iowa); Kinderhook limestone: Sedalia.

Although Miller's type specimen is very imperfect, and the figures show not even the generic characters, there would be

much hesitancy in recognizing the species at all were it not for the fact that good individuals were obtained at the typical localities long before the description of *A. blairi* appeared; and consequently the form was already pretty well understood when the diagnosis was published. Furthermore, it has been deemed advisable, notwithstanding the somewhat doubtful identity of the two forms, to adopt Miller's term, rather than to propose a new name and place *A. blairi* among the spurious species where it ordinarily would belong. This slender form seems to be widely distributed geographically.

Amplexus fragilis White & St. John.

Amplexus fragilis White & St. John, 1867: Trans. Chicago Acad. Sci., vol. I, p. 116.

Amplexus bicostatus Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rept., p. 8, pl. i, fig. 10.

Amplexus coraloides (Many authors; not Sowerby, 1814).

Corallum simple, rather large, long, slender, cylindrical, somewhat annulated, about two centimeters in diameter and from 20 to 30 centimeters long; walls thin. Calyces moderately deep; lamellæ but slightly developed, 32 to 40 in number; transverse diaphragms numerous. Surface rather distinctly marked by longitudinal lines.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia, Louisiana; Keokuk limestone: Boonville; Keokuk (Iowa).

Zaphrentis acuta White & Whitfield.

Plate xiii, fig. 4.

Zaphrentis acuta White & Whitfield, 1862: Jour. Boston Soc. Nat. Hist., vol VIII, p. 306.

Zaphrentis acuta Winchell, 1865: Proc. Acad. Nat. Sci., Phila., 111.

Zaphrentis parasitica Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 79, pl. x, figs. 5–5a.

Corallum small, very robust, or subturbinate, slightly curved, usually pointed at the base; often bulging in the middle. Calyx oblique to the axis; moderately deep, with about 32 lamellae.

Horizon and localities.—Lower Carboniferous, Kinderhook limestone: Clarksville and Louisiana (Pike county).

Z. acuta was first recorded from Missouri by Winchell. The mention of this species in the same connection with *Z. ida*, with the locality given as Clarksville, has led some to believe that *Z. ida* was the species noted from the State; whereas Winchell's species was actually from Indiana, and is not known as yet west of the Mississippi river. Besides, *Z. ida* is a very different form. *Z. parasitica*, recently described by Worthen from the same place, appears to be merely an immature individual that is attached to the shell of a brachiopod.

Zaphrentis calceola White & Whitfield.

Lophophyllum calceola White & Whitfield, 1862; Proc. Boston Soc. Nat. Hist., vol. VIII, p. 305.

Zaphrentis calceola White, 1883; U. S. Geol. and Geog. Sur. Ter , 12th Ann. Rep., p. 156, pl. xxxix, figs. 6a-d.

Zaphrentis calyculus Miller, 1891; Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 10, pl. i. figs. 13-14.

Corallum small, subturbinate, more or less curved, moderately but irregularly expanding from the base upward on the outer side of the curvature, especially at the lower portion, but elsewhere somewhat regularly rounded; apex small, pointed. Calyx moderately deep; principal lamellæ about 32 in number; fossette subcentral, but extending toward the side of the convex curve of the corallum. Surface rugose from unequal growth. Extreme length of an average example, 18 millimeters; diameter of the calyx, about nine millimeters.

Horizon and localities.—Lower Carboniferous, Kinderhook limestone: Sedalia, Clarksville, Hannibal, Louisiana; also Burlington (Iowa).

This form was originally described from Burlington, Iowa. The above is Dr. White's description of the specimens obtained by Professor Broadhead at Sedalia, in the upper portion of the Chouteau limestone.

Zaphrentis tenella MILLER.

Plate xlii, fig. 10.

Zaphrentis tenella Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rept., adv. sheets, p. 11, pl. i, figs. 17, 18.

A small, rather slender form, slightly curved and somewhat twisted, with the calycinal margin very oblique to the axis of the corallnm. Lamellæ about 24 in number.

Horizon and localities.—Lower Carboniferous, Kinderhook limestone: Sedalia, Louisiana.

Zaphrentis tantilla MILLER.

Zaphrentis tantilla Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rept , adv. sheets, p. 11, pl i, figs. 23, 24.

Corallum small, very slender, but slightly curved, with 20 to 32 lamellæ.

Horizon and localities.—Lower Carboniferous, Kinderhook limestone: Sedalia; Burlington limestone: Louisiana, Hannibal.

Zaphrentis cylindracea WORTHEN.

Plate xiii, fig. 5.

Zaphrentis cylindracea Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 78, pl. ix, figs. 5, 5a.

Corallum long, slender, cylindrical, very slightly curved. Calyx moderately deep; septal fossette not prominent. Lamellæ 32 to 40 in number. Epithecal surface not wrinkled.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Genevieve; Chester (Illinois).

Zaphrentis elliptica WHITE.

Plate xiii, figs. 6a-b.

Zaphrentis elliptica White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 31.

Zaphrentis elliptica White, 1883: U. S. Geog. and Geol. Sur. Ter., 12th Ann. Rept., p 155, pl. xxxix, figs. 4a-b.

Zaphrentis carinata Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 75, pl. x, figs. 3-3a.

Corallum rather below medium size, robust, slightly curved, somewhat compressed below the middle. Calyx rather deep,

with the septal fossette prominent; lamellæ well defined, about 40 in number in the average mature individuals. Epithecal crust smooth, rarely wrinkled.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Louisiana; Kinderhook (Illinois); Bonaparte (Iowa).

Zaphrentis chouteauensis MILLER.

Zaphrentis chouteauensis Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rept., adv. sheets, p. 8, pl. i, figs. 11-12.

Somewhat like *Z. calceola*, with the calyx very oblique to the axis of the corallum.

Horizon and localities.—Lower Carboniferous, Kinderhook (Chouteau) limestone: Sedalia.

Zaphrentis exigua MILLER.

Zaphrentis exigua Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep, adv. sheets, p. 11, pl. i, figs. 19-20.

This form is characterized by its minute size, attenuated base and rapidly expanding corallum.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Zaphrentis centralis WORTHEN.

Zaphrentis centralis Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 72, pl. ix, figs. 1-1a; and pl. x, figs. 13-13a.

A large, rather robust form like *Z. dalei*, but with fewer lamellæ and apparently no indications of spines on the outer surface.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Louisiana, Hannibal, Helton (Marion county), Ash Grove, Springfield, Sedalia, Ste. Genevieve; Keokuk limestone: La Grange, St. Francisville (Clark county); Keokuk and Bonaparte (Iowa); Warsaw (Illinois).

Although Worthen's diagnosis of this form is very unsatisfactory, it is quite evident that he had in hand the widely distributed type so common throughout the Burlington and Keokuk rocks of the states of Missouri, Iowa and Illinois. The species appears to be especially abundant in the Burlington

beds. Insofar as present observation goes, no traces of the spinous processes on the epithecal surface have yet been noted; and this difference seems to readily distinguish this form from *Z. dalei* and *Z. spinulosa,* with which it is usually associated and liable to be confounded.

Zaphrentis illinoisensis Worthen.

Zaphrentis illinoisensis Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 77, pl. ix, figs. 4–4a.

Corallum large, rather short, but slightly curved; rapidly expanding to the calycinal margin, where it is very broad. Epithecal folds transverse, unusually wide, prominent. Lamellæ large, widely separated and seldom exceeding 40 in number.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county); Warsaw (Illinois); Keokuk and Bonaparte (Iowa).

Zaphrentis dalei Edwards & Haime.

Plate xiii, fig. 12.

Zaphrentis dalei Edwards & Haime, 1851: Monog. d. Polyp. Foss. d. Ter. Pal., p. 329.

Zaphrentis dalei Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 71, pl. x, figs. 12–12a.

Corallum simple, large, elongate-conical, more or less curved. Calyx somewhat oblique, subcircular, deep; septal fossette well defined and located on the side of least curvature. Lamellæ forty to sixty or more in number, rather prominent, thin, somewhat irregular and usually more or less bent toward the center. External surface rugose and covered by short, widely scattered spines.

Horizon and localities.—Lower Carboniferous, Keokuk limestone and shales: St. Francisville, Boonville, Canton; Burlington limestone: Hannibal, Louisiana, Springfield.

From Warsaw Worthen has described three other species of Zaphrentis: *Z. illinoisensis*, *Z. spergenensis* and *Z. varsaviensis,* whose affinities are not as yet fully understood. They also occur at various places in Missouri, along with numerous other forms apparently undescribed. The original specimens of Edwards & Haime also came from Warsaw, just across the

river from Alexandria, Clark county. The form seems to be widely distributed in the Keokuk rocks of the Mississippi basin, and probably occurs also in the Burlington beds.

Zaphrentis spinulosa EDWARDS & HAIME.

Zaphrentis spinulosa Edwards & Haime, 1851: Monog. d. Polyp. Foss. d. Ter. Pal., p. 334.

Zaphrentis spinulifera Hall, 1858: Geol. Iowa, vol. I, p. 650, pl. xxii, figs. 1a-b.

Zaphrentis spinulosa Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p 73, pl. x, figs. 6-6a.

Zaphrentis pellaensis Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 74, pl. ix, figs. 6-6a; and pl. x, figs. 11-11a.

Very similar to *Z. dalei* Ed. & H., but much smaller, more robust and highly spinous.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Curryville, St. Francisville, Boonville, Keokuk (Iowa); Saint Louis limestone: Clark and Saint Louis counties, and in Iowa at Fort Dodge, Pella, Fairfield, Mt. Pleasant and elsewhere; Kaskaskia limestone: Ste. Genevieve.

Zaphrentis spinulosa is very much like immature individuals of *Z dalei*, but the much greater abundance of the epithecal spines, the usually much broader calycinal disk, seem sufficient to distinguish it from that species. The form appears most characteristic of the Saint Louis limestone, in which it is widely distributed geographically. It also occurs abundantly in the upper portion of the Keokuk limestone, and is found sparingly in the Kaskaskia. Hall's form, *Z. spinulifera*, originally described from Warsaw, Illinois, is without doubt identical with the species under consideration, and is so regarded here.

Zaphrentis varsavenis WORTHEN.

Zaphrentis varsavensis Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 78, pl. x, figs. 9-9a.

A small, symmetrical, moderately curved form, with 20 to 32 lamellæ.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: LaGrange, Warsaw (Illinois).

Zaphrentis spergenensis Worthen.

Zapprentis spergenesis Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 77, pl. x, figs. 8-8a.

Small, moderately slender, spiniferous; very similar to immature individuals of *Z. spinulosa,* and possibly identical with that species.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county), Boonville; Keokuk (Iowa); Warsaw (Illinios).

Zaphrentis chesterensis Worthen.

Zaphrentis chesterensis Worthen, 1890: Geol. Sur. Illnois, vol. VIII, p 73, pl. ix, figs. 3-3a.

Corallum like *Z. dalei,* but rather more slender, less curved, and with only occasional indications of spines. The septal fossette is also less distinctly defined.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Genevieve.

Lophophyllum proliferum (McChesney)

Plate xiii, figs. 8a-b.

Cyathaxonia prolifera McChesney, 1860: Desc. New Palæ. Foss., p. 75.

Cyathaxonia prolifera McChesney, 1867: Trans. Chicago Acad. Sci., vol. 1, p. 1, pl. ii, figs. 1-3.

Cyathaxonia sp? Grinitz, 1866: Carb. und Dyas in Nebraska, pp. 65, 66, tab. v, figs. 3-4.

Lophophyllum proliferum Meek, 1872: U. S. Geol. Sur. Nebraska, p. 144. pl. v, figs. 4a-b.

Lophophyllum proliferum White, 1892: U. S. Geog. Sur. w. 100 Merid., vol. IV, p. 101, pl. vi, figs. 4a-d.

Lophophyllum proliferum White, 1884: Geol. Sur. Indiana, 13th Ann. Rept., pt. ii, pl. xxiii, figs. 6, 7.

Lophophyllum proliferum Keyes, 1888: Proc. Acad. Nat. Sci., Phila., p. 225.

Corallum simple, rather small, elongate-subconical, more or less curved; transversely wrinkled and longitudinally striated, often somewhat spinous; calyx circular, rather deep: columella well-defined; lamellæ 20 to 50 in number.

Horizon and Localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Chonophyllum sedaliense WHITE.

Plate xiv, fig. 9.

Chonophyllum sedaliense White, 1883: Twelfth Ann. Rep. U. S. Geol. and Geog. Sur., p. 157, pl. xxxix, fig. 3a.

"Corallum moderately large, approximately straight, the angle of divergence of its sides being quite small; calyx apparently rather shallow; rays numerous; surface rough by the presence of numerous projecting, successive calyx borders, and by coarse, irregular, longitudinal striæ. Length probably about 130 millimeters; and the diameter of the calyx about 30 millimeters." (White.)

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Columnaria stellata? (HALL).

Plate xiii, fig. 3.

Favistella stellata Hall, 1847: Pal. New York, vol. I, p. 275, pl. lxxv, figs. 1a-c.

Columnaria stellata Rominger, 1876: Geol. Sur. Michigan, vol. III, pt. ii, p. 91, pl. xxxiv, fig. 3.

Corallum of medium size, hemispherical or flattened spheroidal. Corallites radiating from a central point, four to five millimeters in diameter; lamellæ not very well defined; dissepiments flat, numerous.

Horizon and localities.—Lower Silurian, Trenton limestone: Cape Girardeau.

Hadrophyllum glans WHITE.

Plate xiii, figs. 11a-b.

Zaphrentis glans White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 32.

Hadrophyllum glans White, 1883: U. S. Geol. and Geog. Sur. Ter., 12th Ann. Rept., p. 156, pl. xxxix, figs. 5a-b.

Corallum small, somewhat globose; base small, pointed, well defined; calyx flattened or convex, with a rather well-marked margin, and very oblique to the axial line. Septal fossettes three in number, the principal one quite large, rather shallow, with its chief axis coinciding with the long diameter

of the oval calycinal disk and extending nearly to the border. Septa prominent; 20 to 40 in number, with numerous rudimentary ones.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Louisiana, Sedalia.

Microcyclus blairi Miller.

Microcyclus blairi Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 7, pl. ix, figs. 27-28.

Much like Hadrophyllum in general appearance, but very short and discoid.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Streptelasma corniculum Hall.

Plate xiii, fig. 9.

Streptelasma corniculum Hall, 1847: Pal. N. Y., vol. 1, p. 69, pl. xxv, figs. 1a-e.

Streptelasma corniculum White, 1882: Geol. Sur. Indiana, 11th Ann. Rept., p. 376, pl. li, figs. 2-4.

Streptelasma corniculum Rominger, 1876: Geol. Sur. Michigan, vol. III, (ii), p. 142, pl. li, fig. 1.

Corallum simple, conical to elongate-conical, slightly and regularly curved. Calyx moderately deep; lamellæ rather heavy, 80 to 120 in number. Epithecal crust rather well developed, longitudinally striated, and often with fine traversed wrinkles.

Horizon and localities.—Lower Silurian, Trenton limestone: Cape Girardeau, Cyrene (Pike county).

Cystophyllum americanum Edwards & Haime.

Plate xiv, figs. 4a-b.

Cystophyllum americanum Edwards & Haime, 1851: Monog. Polyp. Foss. d. Terr. Palæ., p. 464.

Cystophyllum americanum Rominger, 1876: Geol. Sur. Michigan, vol. III, pt. ii, p. 183, pl. 1, fig. 1.

Corallum of medium size, simple, conical, moderately curved. Calyx deep, blistered; radial ridges more or less obsolete. Surface of epithecal wall concentrically wrinkled.

Horizon and localities.—Devonian, Calaway limestone: Winfield (Lincoln county).

Palæacis enormis (Meek & Worthen).

Sphenopterium enorme Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila. p. 448.
Sphenopterium enorme Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 146, pl. xiv, figs. 1a-b.
Sphenopterium enorme var. *depressum* Meek & Worthen, 1866: Geol. Sur. Illinois, vol II, p. 146, pl. xiv, figs. 2a-b.
Palæacis enormis Miller, 1877: Cat. Am. Palæ. Foss., p. 43.
Palæacis enormis var. *depressa* Miller, 1877: Cat. Am. Palæ. Foss., p 43.

Similar to *P. obtusa*, but usually smaller and cells fewer in number.

Horizon and locality.—Lower Carboniferous, Kinderhook: Clarksville and Louisiana (Pike county).

Palæacis obtusa (Meek & Worthen).

Plate xiv, figs. 1a-b.

Sphenopterium obtusum Meek & Worthen, 1860: Proc. Acad. Nat Sci., Phila., p. 448.
Sphenopterium compressum Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 448.
Sphenopterium obtusum Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 233, pl. xvii, figs. 2a-e.
Sphenopterium compressum Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p 234, pl. xvii, figs. 1a-c.
Palæacis obtusa Miller, 1877: Cat. Am. Palæ. Foss., p. 43.
Palæacis compressa Miller, 1877: Cat. Am. Palæ. Foss, p. 43.

Corallum rather small, more or less distinctly wedge-shaped, with the width somewhat greater than the height; sides ornamented by fine, irregular or vermicular markings. Corallites three to ten or more in number, rather large, deep, more or less conical in shape, round or polygonal; septa 30 to 40 in number, usually appearing in fine raised lines.

Horizon and localities.— Lower Carboniferous, Keokuk limestone; Clark county.

Conopterium effusum Winchell.

Plate xiv, fig. 10.

Conopterium effusum Winchell, 1855: Proc. Acad. Nat. Sci, Phila., p. 111.

Corallum small, adherent, subspherical; composed of numerous unequal, crowded corallites, which enlarge rapidly from

the base or point of attachment. Cells distinctly lined within, and covered externally by rather thick, wrinkled epitheca.

Horizon and localities.—Lower Carboniferons, Kinderhook limestone: Clarksville and Louisiana (Pike county).

Generically Conopterinm is clearly distinct from Palæacis and Sphenopterinm. The corallites are much smaller and more variable in size than in any known species of the two genera mentioned. The coralla appear to have been attached to molluscan shells or other submerged objects; and as they grew to be of large size, the lower or marginal cells adhered firmly to the surface of attachment.

Cleistopora placenta (White).

Plate xlv, fig. 11.

Michilinia placenta White, 1883: Twelfth Ann. Rep. U. S. Geol. and Geog. Sur., p. 157, pl. xxxix, figs. 2a-b.

Very similar to *L. typa*, but much larger; the corallites have a diameter two to three times the size of the typical species, while the coralla attain a measurement of 10 to 14 cm.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia, Curryville (Pike county).

The species under consideration is seldom well preserved, and its structural characters are consequently usnally difficult to make out satisfactorily. It appears beyond doubt that this form is not properly a Michilinia; and there are good reasons for believing that it is congeneric with Winchell's *Leptopora typa*, though the exact systematic position of that genus has not as yet been made out fully.

From a comparison of a large series of specimens from White's original locality it would seem that the two species that he recognized are indentical.

Cleistopora typa Winchell.

Leptopora typa Winchell, 1863: Proc. Acad. Nat. Sci., Phila., p. 3.

Leptopora typa White, 1883: Ge.l. and Geog. Sur. Ter., 12th Ann. Rep., p. 122, pl. xxxiv, figs. 12a-b.

Leptopora gorbyi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., Ad. Sheets, p. 6, pl. 1, figs. 1-4.

Corallum forming thin discoidal expansions; with a well-defined, concentrically wrinkled epitheca. Corallities few,

polygonal, separated by a common wall. Calyces shallow, with 30 to 40 or more rudimentary septa, which usually appear as vertical striations.

Horizon and localities. — Lower Carboniferous, Kinderhook: Sedalia.

The precise affinities of this group of organisms is not thoroughly understood at present; so that the synonymy of the genus cannot be given with certainty. Considerable variation is observable both in the size of the corallites and in the number of their septal rudiments. In case of the latter the number is known to be as few as twenty, as stated by Winchell, and to range as high as forty or more.

Favosites hemispherica (Troost).

Plate xiv, fig. 3.

Calamopora hemispherica Troost, 1840: Geol. Tennessee, p. 72.
Favosites hemispherica Yandell & Shumard, 1847: Cont. Geol. Kentucky, p. 7.
Favosites hemispherica Rominger, 1876: Geol. Sur. Michigan, vol. III, pt. ii, p. 25, pl. vi, figs. 1–4.

Corallum rather small in size, usually more or less distinctly globular in shape, sometimes flattened or cylindrical. Corallites unequal in size, polygonal, 2 to 3 millimeters in diameter as a rule, diverging in broad curves from the central axial line; interior smooth, with simple, flat dissepiments which are rarely compound; mural pores large, with seldom more than a single row on a side.

Horizon and localities. — Upper Silurian, Niagara limestone: Edgewood (Pike county), St. Louis county.

Favosites favosa? (Goldfuss).

Plate xiv, fig. 2.

Calamopora favosa Goldfuss, 1826: Germ. Petrif., p 77.
Calamopora favosa Hall, 1852: Pal. N. Y., vol. II, p. 125.
Favosites favosa Rominger, 1976: Geol. Sur. Michigan, vol. III, pt. ii, p. 21, pl. iv, figs. 1–4.

Corallum often attaining a large size. Corallites polygonal, of tolerably uniform size in the same masses, but ranging from two to five millimeters in diameter in different individuals; interior ribbed longitudinally, the intervening space between

this striations being beset with small spinous processes. Dissepiments usually flat or slightly convex, but not unfrequently quite concave, slightly deflected at the margin in front of the longitudinal furrows. Mural pores of medium size, rather numerous. Epitheca considerably wrinkled.

Horizon and localities—Upper Silurian, Niagara? oolite: Edgewood (Pike county); and Auburn (Lincoln county).

Striatopora missouriensis Meek & Worthen.

Striatopora missouriensis Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 369, pl. vii, fig. 4.

Growths very similar to those of *S. carbonaria*, but more slender and with the tube openings much less numerous.

Horizon and localities—Upper Silurian limestone: Bailey landing (Perry county).

Striatopora carbonaria White.

Plate xlv, fig. 7.

Striatopora carbonaria White, 1862: Trans. Boston Soc. Nat. Hist., vol. IX, p. 32.

Small, slender, dichotomous growths from three to five millimeters in diameter. Tubes very thick-walled, directed obliquely upward and outward; the openings about two millimeters in diameter, dilated slightly, with a sharp semi-circular ridge on exterior side.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Ste. Genevieve, Hannibal; Burlington (Iowa).

Syringopora harveyi? White.

Plate xiv, fig. 6a.

Syringopora harveyi White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 32.

Corallum large, hemispherical. Corallites large, rather distinct, wrinkled; connecting tubules far apart. Otherwise very similar to *S. multattenuata.*

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville (Cooper county), Canton (Lewis county), Curryville (Pike county).

It is with considerable doubt that the Keokuk forms are referred to White's *S. harveyi*, but the same species occurs in the Burlington limestone. In consequence, therefore, of the inability to make out any marked distinctions between the two forms, it seems advisable to refer the Keokuk fossils to *S. harveyi.*

Syringopora sp?

Plate xiv, fig. 5.

Horizon and locality —Lower Carboniferous, Kinderhook limestone: Kinderhook (Illinois).

Syringopora multattenuata McChesney.

Plate xiv, fig. 6b.

Syringopora multattenuata McChesney, 1860: Desc. New Pal. Foss., p. 75.
Syringopora multattenuata McChesney, 1867: Trans Chicago Acad. Sci., vol. I, p. 2, pl ii, fig. 4.
Syringopora multattenuata Meek, 1872: U. S. Geol. Sur. Nebraska, p. 144, pl. i, figs. 5a-d.
Syringopora multattenuata White, 1877: U. S. Geog. Sur. w. 100 Merid., vol. IV, p. 100.

Corallum occurring in rather large, more or less spherical masses, made up of slender, flexuous corallites, which are long, cylindrical, somewhat radiating and completely separated from one another, except at the points where the connecting tubes are given off; these copulatory protuberances are quite numerous, rather slender and closely though somewhat irregularly set. Epitheca thick and considerably wrinkled. Tabulæ obliquely and irregularly arranged.

Horizon and localities — Carboniferous, Upper Coal Measures: Kansas City.

Although the corallum of this species usually forms more or less globular masses from three to six inches in diameter, large flattened expansions attaining a size of ten or more inches are occasionally met with. Owing to the peculiar fragile character, these masses are seldom found entire, yet the fragmentary pieces are not uncommon. In size the corallites are quite uniform, the diametric measurement being as a rule a little less than one-tenth of an inch. The spaces between

the different corallites vary considerably, even in the same specimen, while the flexuous nature of the several cylinders makes the irregularity all the more apparent. Not unfrequently the corallites are so close together as to resemble certain forms of Favosites.

Aulopora gracilis *sp. nov.*

Plate xiv, fig. 8.

Prostrate expansions of conical tubules which are arranged in long lines, bifurcating or not, the basal end of each successive tubule being given off from near the orificial extremity of the one behind it. Oral portions erect, with the opening about two millimeters in diameter, and expanding rather rapidly at the margin.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Hannibal; Burlington (Iowa); Keokuk limestone: Boonville (Cooper county); Keokuk (Iowa).

This species approaches nearer than any other *A. conferta*, Winchell, from the Hamilton rocks of Michigan. The tubules, however, are stouter, shorter, the oral parts more elevated and the immediate orifice more campanulate than in the Devonian examples. The form is rather widely distributed both geographically and geologically. It is believed that the Burlington and Keokuk specimens are identical, and that the form occurring in the Kinderhook is also to be referred to the same species.

Chætetes milleporaceus Troost.

Plate xiv, figs. 12a-b.

Chætetes milleporaceus Troost, 1849: (Ms.).
Chætetes milleporaceus Edwards & Haime, 1851: Monog. Polyp. Foss., p. 272.
Chætetes milleporaceus White, 1877: Geog. Sur. w. 100 Merid., vol. IV, p. 98, pl. vi, fig. 2a.

Corallum rather large, massive, subglobose; made up of fine, closely arranged corallites, having a diameter of one-fourth to one-third of a millimeter.

Horizon and localities. — Carboniferous, Upper Coal Measures: Glasgow.

Chætetes, as at present understood, embraces only a few Carboniferous forms. Formerly the name was applied indifferently to a large number of fossils, many of which are now known to have no affinities whatever to the original type. The genus has thus come to include a great many species whose exact zoological relations are not fully understood. Even at the present time there is a considerable diversity of opinion concerning the correct systematic position of the group; and much remains to be learned of its structural characters. Most of the forms that have been placed under Chætetes really belong to various families of Polyzoans, especially the earlier species, from the Silurian rocks.

DOUBTFUL SPECIES OF CORALS.

Lithostrotion microstylum White, 1883: Twelfth Ann. Rep. U. S. Geol. and Geog. Sur., p. 150, pl. xl, fig. 7a.

Too imperfect for description; and so far as is known no specimen has been obtained since the finding of the type, of which there is also some doubt as to the locality. Lower Carboniferous, Chouteau limestone, Sedalia.

CHAPTER VI.

ECHINODERMS: ECHINOIDS.

Melonites multipora NORWOOD & OWEN.

Plate xvi, figs. 1a-b; and plate xvii, figs. 1a-c.

Melonites multipora Norwood & Owen, 1846: Am. Jour. Sci., (2), vol. II, p. 222, figs. 1, 2, 3.

Melonites multipora Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 228.

Melonites irregularis Hambach, 1884: Trans. St. Louis Acad. Sci., vol. III, p. 549, pl. C, fig. 2.

Test large, spherical, with 10 meridional folds, of which the ambulacral are the narrower. Ambulacral areas about two-thirds the width of the interambulacra, each composed of about 10 rather poorly defined rows of very irregular pore-plates, the ossicles of the central two ranges being about three times as large as the others. The interambulacral areas each have eight rows of hexagonal ossicles, the marginal ones being only about half the width of the others; toward the poles, however, the plates are somewhat irregular and the ranges are not distinctly defined. The apical disk is rather small in size; the oculars are very small, only about one-fifth the size of the genitals, quadrangular in outline, and so far as is known, have not been observed to be perforated. The genitals are quite large, sub-pentagonal in shape, one being slightly larger than the other four. The madreporic plate is perforated by numerous very minute openings, with apparently a single large one. The two genitals nearest the madreporite have each four large perforations, and the two opposite each three. The number of holes in the genital plates appears to differ somewhat in different specimens. The oral aperture is rather small, subcircular in outline. Five strong triangular jaws have been observed

within the peristome of some specimens. The surface of the test is covered by numerous small granules, which support the spines, about 30 occupying each interambulacral plate.

Horizon and localities.—Lower Carboniferous, St. Louis limestone: St. Louis.

Melonites crassus HAMBACH.

Melonites crassus Hambach, 1884: Trans. St. Louis Acad. Sci., vol. IV, p. 548, pl. C., fig. 1.

Closely resembling *M. multipora*, but with only five rows of interambulacral plates, the latter being also larger and covered with larger spines.

Horizon and Localities.—Lower Carboniferous, St. Louis limestone: St. Louis.

Oligoporus mutatus Sp. Nov.

Plate xv, figs. 4a-b.

Test rather large, spherical, lobed. Interambulacral areas rather broad, moderately convex, composed of five vertical ranges of large hexagonal plates. Ambulacral areas less than half the width of the interambulacral, very convex or sharply angular; pore-plates small, very low, but wide, in four rows, the median pair being about twice as wide as the outer ones. Surface covered by small spine tubercles.

Horizon and localities—Lower Carboniferous, Keokuk limestone: Keokuk (Iowa).

As distinguished from *O. danæ*, this form is somewhat smaller in size, with the ambulacral areas much more elevated centrally and the bordering furrows much more shallow. In the interambulacral areas there are only five instead of nine vertical rows of plates.

Oligoporus danæ (MEEK & WORTHEN).

Plate xvii, figs. 2a-b.

Melonites danæ Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 397.

Oligoporus danæ Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 249, pl. xvii, fig. 8.

Test large, spherical. Interambulacral areas lanceolate in outline, moderately convex, occupied below the middle by nine vertical ranges of plates. Ambulacral areas about half as wide as the others, and nearly as convex, the broad, rounded furrow on each side of the middle rather shallow. Pore-plates in four rows, much wider than high, and somewhat irregular. Surface covered with small tubercles at the spine bases.

Horizon and localities—Lower Carboniferous, Keokuk limestone: Felton (St. Louis county), Curryville (Pike county); Keoknk (Iowa).

Oligoporus parvus HAMBACH.

Oligoporus parvus Hambach, 1884: Trans. St. Louis Acad. Sci., vol. IV, p. 550, pl. C, fig. 3.

Like *O. danæ* but somewhat smaller.

Horizon and locality.—Lower Carboniferous, St. Louis limestone: St. Louis.

Archæocidaris agassizi HALL.

Plate xv, fig. 5.

Archæocidaris agassizi Hall, 1858: Geol. Iowa, vol. I, p. 698, pl. xxvi, figs. 1a–d.

Known only from loose plates and spines. Interambulacral plates of medium size, hexagonal, except the marginal ones, which are subpentagonal. Central tubercle large, occupying two-thirds the superficial area of plate, rather high; base small, perforated. Surface of plates smooth except along the margins, which are deeply crenulated, or marked by a marginal series of elongated confluent nodes. Spines long, stout, somewhat compressed, contracted below, bluntly pointed above; socket deep; annulation rather coarsely striated. Surface of the spine below, smooth; above marked by numerous small spinous tubercles, arranged in oblique rows, or quincunx order.

Horizon and localities—Lower Carboniferous, Burlington limestone: Hannibal; Burlington (Iowa).

Archæocidaris shumardana Hall.

Archæocidaris shumardana Hall, 1858: Geol. Iowa, vol. I, p. 699, pl. xxvi, figs. 3a-d.

Spines and plates as in *A. agassizi*, but only about one-third as large.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: La Grange (Lewis county).

Archæocidaris keokuk Hall.

Archæocidaris keokuk Hall, 1858: Geol. Iowa, vol. I, p. 699, pl. xxvi, figs. 2a-b.

Known only from fragments. Plates with the marginal nodes more prominent and further apart than in *A. agassizi*, and the central tubercles also smaller. Spines less than two-thirds the size of those of the species just mentioned.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Clark county (apparently); Warsaw (Illinois).

Archæocidaris wortheni Hall.

Plate xvi, figs. 3a-b.

Archæocidaris wortheni Hall, 1858: Geol. Iowa, p. 700, pl. xxvi, figs. 4a-g.

Test subglobose. Interambulacral areas made up of four rows of large hexagonal plates; central tubercle about half as broad as the plate, with the boss moderately elevated; surface of the plates glabrate except at the borders when the marginal row of nodes is quite narrow. Ambulacral area narrow, about half as wide as the large hexagonal ossicles, composed of rectangular plates, which are about twice as wide as high and have a pair of large oval pores, about 10 occupying the height of an interambulacral piece. Spines rather small, slender, slightly curved, with an apparently smooth or finely granular surface; below expanding rapidly into the broad crenulated annulation.

Horizon and localities.—Lower Carboniferous, St. Louis limestone: St. Louis.

Archæocidaris newberryi Hambach.

Archæocidaris newberryi Hambach, 1884: Trans. St. Louis Acad. Sci., vol. IV, p. 551, pl. D, fig. 1.

Very closely related, and probably identical with, *A. shumardana.*

Horizon and localities.—Lower Carboniferous, Lower St. Louis limestone: St. Louis.

Archæocidaris norwoodi Hall.

Archæocidaris norwoodi Hall, 1858: Geol. Iowa, vol. I, p. 701, pl. xxvi, figs. 5a-e.

Interambulacral plates with smaller tubercles than in *A. agassizi.* Spines small, slender, with sharp, scattered spinous processes on the upper half.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Kaskaskia (Illinois). Reported also from near St. Louis.

Archæocidaris hallianus (Geinitz).

Eocidaris hallianus Geinitz, 1866: Carb. und Dyas in Nebraska, p. 61, tab. v, figs. 1a-b.

Eocidaris hallianus Meek, 1872: U. S. Geol. Sur. Nebraska, p. 152, pl. vii, figs. 9a-d.

A very small form, with spines about a centimeter in length.

Horizon and localities.—Upper Carboniferous, Upper Coal Measnres: Kansas City.

If the identification of the Kansas City specimen is correct, it seems probable that this form should more properly come under Archæocidaris rather than Eocidaris.

Archæocidaris megastylus Shumard.

Plate xv, figs. 2a-b.

Archæocidaris megastylus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 225.

Known only from loose spines and plates. Interambulacral plates very large and heavy, hexagonal, margins slightly turned upward; central tubercle large, considerably elevated;

marginal nodes rather small, distant. Surface smooth. Spines large, attaining a length of 8 or 9 centimeters; very heavy, and nearly of a uniform size throughout the entire length. A few long spinous projections stud the surface at irregular distances.

Horizon and localities.— Upper Carboniferous, Upper Coal Measures: Independence (Jackson county).

Archæocidaris biangulata Shumard.

Plate xv, figs. 1a-c.

Archæocidaris biangulata Shumard, 1858: Trans. St. Louis Acad. Sci. vol. I, p. 224.

Interambulacral plates as in *A. agassizi*, but somewhat wider than high, and with the boss much larger. Spines moderately stout, with a broad alate extension running longitudinally on opposite sides from near the crenulated annulation to the end. Both the central thickened portion of the spine and its expansions are covered by small scattered spinous tubercles.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Lexington, Kansas City.

Archæocidaris aculeata Shumard.

Plate xv, fig. 3.

Archæocidaris aceulata Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 223.

Archæocidaris verneuiliana Swallow, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 180. (Not King, Per. Foss., pl. vi, figs. 22–24.)

Archæocidaris gracilis Newberry, 1861: Rept. Colorado Riv. West, Ives' Exp., p. 117, pl. i, figs. 4-4a.

Known only from spines, which are long, slender, with numerous short spinous processes, lower part contracted somewhat.

Horizon and localities—Upper Carboniferous, Upper Coal Measures: New Point (Jackson county).

Archæocidaris dininnii White.

Archæocidaris dininnii White, 1880: Proc. U. S. National Museum, vol. II, p. 260, pl. i, figs. 13-14.

Archæocidaris dininnii White, 1883: U. S. Geog. and Geol. Sur. Terr., 12th Ann. Rep., p. 131, pl. xxxv, figs. 6a-b.

Primary spines long, subfusiform, covered by long, scattered spinous processes.

Horizon and localities—Upper Carboniferous, Upper Coal Measures: Kansas City.

ASTEROIDS.

Onychaster asper Miller.

Onychaster asper Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 74, pl. xii, figs. 3-4.

Horizon and locality—Lower Carboniferous, Keokuk limestone: Boonville (Cooper county).

This and two other similar, if not identical, species from the same place are the first records of the group from Missouri.

CHAPTER VII.

ECHINODERMS: CYSTIDS AND BLASTOIDS.

Comarocystites shumardi MEEK & WORTHEN.

Plate xviii, fig. 2.

Comarocystites shumardi Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., p. 143.

Comarocystites shumardi Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 292, pl. i, figs. 1a-b.

Calyx obovate, height slightly more than width. Basals wider than long, rather irregular in shape; succeeding ranges of plates very irregularly arranged and differing in form, but increasing in size upward, chiefly hexagonal and heptagonal; all deeply concave externally, with prominent ridges at the sutures.

Horizon and locality —Lower Silurian, Trenton limestone: Cape Girardeau.

Comarocystites obconicus MEEK & WORTHEN.

Plate xviii, fig. 1.

Comarocystites shumardi var. *obconicus* Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., p. 144.

Comarocystites shumardi var. *obconicus* Meek & Worthen, 1866: Geol. Sur. Illinois, vol. III, p. 294, pl. i, figs. 2a-b.

Calyx closely resembling *C. shumardi,* but smaller and longer.

Horizon and locality.—Lower Silurian, Trenton limestone: Cape Girardeau.

Echinodiscus kaskaskiensis (HALL).

Plate xviii, fig. 3.

Agelacrinus kaskaskiensis Hall, 1858: Geol. Iowa, vol. I, p. 696, pl. xxv, fig. 18.

Echinodiscus kaskaskiensis Miller, 1891: N. A. Geol. and Pal., p. 241.

Discoid, with an apparently entire apex, from which the rays proceed. Rays six, radiating and curving toward the margin so as to come nearly in contact on the periphery; composed of uniform plates which are crenulate or poriferous at their inter-locking edges. Intermediate spaces occupied by plates of hexagonal or irregular forms, nearly flat. Surface finely granulated. (Hall.)

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Mary (Ste. Genevieve county); Kaskaskia (Illinois).

Echinodiscus sampsoni MILLER.

Echinodiscus sampsoni Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., p. 76, pl. xii, fig. 16.

Almost too imperfect for recognition. From the fragments known, it must have been considerably larger than *E. kaskaskiensis.*

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville (Cooper county).

Pentremites elongatus SHUMARD.

Plate xviii, fig. 4.

Pentremites elongatus Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 187, pl. B, fig. 4.

Pentremites elongatus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 244.

Pentremites elongatus White, 1863: Boston Jour. Nat. Hist., vol. VII, p. 488.

Pentremites elongatus Etheridge & Carpenter, 1886: Cat. Blastoidea, p. 161, pl. i, figs. 4–5.

Calyx elliptical, elongated and attenuated upward, from one and three-quarters to twice as long as wide; summit convex and more or less contracted; base truncated but convex, small, but wider than the summit; section roundly pentagonal; periphery as nearly as possible equatorial. Basal plates small,

forming a shallow, expanded cup; projection of the columnar facet broad and low. Radial plates narrow and very long, quite two-thirds the entire length of the calyx; bodies short and obliquely bent inward, and subangular in the middle line; limbs with parallel margins, steep sides, and very obliquely truncated above; sinuses broadly lanceolate; lips rather prominent; interradial sutures in concavities. Deltoid plates acutely and unequally rhombic, and their surfaces concave; radio-deltoid sutures at about one-third the height of the calyx from the summit. Ambulacra convex extending nearly the entire length of the body, their proximal ends depressed below the edges of the sinuses, but on a level with them distally; lancet-plate as wide as, if not wider than, the combined side plates on each side; ambulacral grooves wide and shallow, but the lateral grooves slightly oblique; side plates oblong, 40 to 50 in number. Three hydrospire-folds on each side; spiricles oval, but often in pairs, and separated by stony septa. Mouth small. Ornament consists of fine lines parallel to the margins of the plates. (Eth. & C.)

Horizon and localities.— Lower Carboniferous, Upper Burlington limestone: Palmyra, Helton and Hannibal in Marion county, Louisiana, Columbia, Rocheport (Boone county), Ash Grove (Greene county), Ste. Genevieve.

Pentremites conoideus Hall.

Plate xviii, fig. 5.

Pentremites conoideus Hall, 1856: Trans. Albany Inst., vol. IV, p. 5.
Pentremites conoideus Hall, 1858: Geol. Iowa, vol. I, p. 655, pl. xxii, figs. 8-10.
Pentremites conoideus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 243, pl. ix, fig. 4.
Pentremites conoideus Etheridge & Carpenter, 1886: Cat. Blastoidea, p. 162, pl. ii, figs. 16-23 (in part).

Like *P. elongatus*, but much smaller and conical.

Horizon and localities.— Lower Carboniferous, Keokuk limestone: Boonville (Cooper county).

Pentremites koninckanus Hall.

Pentremites koninckanus Hall, 1856: Trans. Albany Inst., vol. IV, p. 4.
Pentremites koninckanus Hall, 1858: Geol. Iowa, vol. I, p. 656, pl. xxii, figs. 11a-c.

Closely related to *P. conoideus*, but smaller and more globose.

Horizon and localities.—Lower Carboniferous, St. Louis limestone: St. Louis; Pella and Oskaloosa (Iowa).

Pentremites sulcatus (Rœmer).

Plate xviii, figs. 6a-b.

Pentatrematites sulcatus Rœmer, 1851: Archiv. f. Naturg., Jahrg. xvii, Bd. I, p. 354, pl. vi, figs. 10a-c.
Pentremites sulcatus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 243.
Pentremites missouriensis Swallow, 1863: Trans. St. Louis Acad. Sci., vol. II, p. 81.
Pentremites sulcatus Etheridge & Carpenter, 1886: Cat. Blastoidea, p. 165, pl. i, figs. 8-10.

This species belongs to the *P. obesus* group, but is much smaller than the typical form.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Mary (Ste. Genevieve county).

Pentremites obesus Lyon.

Pentremites obesus Lyon, 1857; Geol. Sur. Kentucky, vol. III, p. 469, pl. ii, figs. 1a-d.
Pentremites obesus Hall, 1858: Geol. Iowa, vol. I, p. 695, pl. xxv, fig. 15.
Pentremites obesus Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 167.

Calyx subglobose, very large and massive.

Horizon and localities—Lower Carboniferous, Kaskaskia limestone: Ste. Mary (Ste. Genevieve county).

Pentremites pyriformis Say.

Pentremites pyriformis Say, 1825: Jour. Acad. Nat. Sci., Phila., vol. IV, p. 294.
Pentremites pyriformis Say, 1825: Zool. Jour., vol. II, p. 314.
Pentremites pyriformis Troost, 1835: Trans. Geol. Soc. Tenn., vol. I, p. 229, pl. x, fig. 8.
Pentremites pyriformis Hall, 1858: Geol. Iowa, vol. I, p. 693, pl.xxv, fig. 6.
Pentremites symmetricus Hall, 1858: Geol. Iowa, vol. I, p. 294, pl. xxv, fig. 14.

Pentremites pyriformis Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila., pl. xvii, fig. 5.

Pentremites pyriformis Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 167, pl. ii, figs. 24-30.

Calyx pyriform, otherwise closely approaching *P. godoni.*

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Mary (Ste. Genevieve county).

Pentremites godoni Defrance.

Encrina godoni Defrance, 1819: Dict. Sci. Nat., t. XIV, p. 467.

Encrinites florealis von Schlotheim, 1820: Petref, Bd. II, p. 38.

Pentremite Say, 1820: Am. Jour. Sci., vol. II, p. 38.

Pentremites florealis Say, 1825: Jour. Acad. Nat. Sci., Phila., vol. IV, p. 295.

Pentremites florealis Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 592.

Pentremites godoni Hall, 1858: Geol. Iowa, vol. I, p. 692, pl. xxv, figs. 13a-b.

Pentremites godoni White, 1881: Geol. Sur. Indiana, 10th Ann. Rep., p. 511, pl. vii, figs. 10-11.

Pentremites godoni Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 157, pl. ii, figs. 1-13.

Calyx globose, otherwise much like *P. elongatus.*

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Ste. Mary (Ste. Genevieve county).

Metablastus lineatus (Shumard).

Plate xviii, fig. 11.

Pentremites lineatus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 241, pl. ix, figs. 3a-2.

Pentremites lineatus White, 1863: Boston Jour. Nat. Hist., vol. III, p. 488.

Troostocrinus lineatus Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 384.

Troostocrinus lineatus Ethridge & Carpenter, 1882: Ann and Mag. Nat. Hist, vol. IX, p. 249.

Metablastus lineatus Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 199, vol. III, figs. 14-15.

Calyx very long, spindle-shaped, summit contracted; base sub-pentagonal above, triangular below; periphery two-thirds the entire distance from the bottom. Basals very long, slender, somewhat rounded above, angular below. Radials elongated, narrow; bodies arched and rather angular medially, sides flattened; sinus quite narrow, deeply cleft. Surface ornamented by fine lines.

Horizon and localities.— Lower Carboniferous, Upper Burlington limestone: Hannibal.

Metablastus bipyramidalis (Hall).

Plate xviii, fig. 13.

Pentremites bipyramidalis Hall, 1858: Geol. Sur. Iowa, vol. I, p. 607, pl. xv, fig. 2.

Metablastus bipyramidalis Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 143.

Similar to *M. wortheni*, but with very much longer ambulacra; and with the periphery about midway between the extremities.

Horizon and localities — Lower Carboniferous, Keokuk limestone: Boonville (Cooper county).

Metablastus wortheni (Hall).

Plate xviii, fig. 12.

Pentremites wortheni Hall, 1858: Geol. Iowa, vol. 1, p. 606, pl. xv, fig. 1.

Pentremites wortheni Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 506, pl. xiv, fig. 11.

Pentremites varsoviensis Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 521, pl. xxxi, figs. 8-9.

Metablastus wortheni Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 143.

Metablastus varsoviensis Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 143.

Very closely related, and perhaps identical with *M. lineatus*, but apparently having longer ambulacra and heavier basal cup.

Horizon and Localities.—Lower Carboniferous, Keokuk limestone: Boonville (Cooper county); Warsaw (Illinois).

Schizoblastus ? roemeri Shumard.

Pentremites roemeri Shumard, 1885: Geol. Sur. Missouri, Ann. Rep., p. 186, pl. B, figs. 2a-d.

Pentremites sampsoni Hambach, 1884: Trans. St. Louis Acad. Sci., vol. IV, p 551, pl. ii, figs. 2-2a.

Schizoblastus sampsoni Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 142.

Resembling *S. sayi* somewhat, but less than one-quarter the size.

Horizon and localities —Lower Carboniferous, Chouteau limestone (Kinderhook): Sedalia, Providence (Boone county).

Schizoblastus melonoides (MEEK & WORTHEN).

Granatocrinus melonoides Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 88.

Granatocrinus melonoides Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 468, pl. ix, fig. 1.

Schizoblastus melonoides Ethridge & Carpenter, 1882: Ann. & Mag. Nat. Hist., art. IX, p. 246.

Schizoblastus melonoides Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 226, pl. VI, figs. 15-16.

Similar to *C. melo* in general appearances, but readily distinguished, aside from the distinctive generic characters, by being much less lobate.

Horizon and localities — Lower Carboniferous, Upper Burlington limestone: Louisiana, Hannibal.

Schizoblastus sayi (SHUMARD).

Plate xviii, figs. 9a-b.

Pentremites sayi Shumard, 1855: Geo. Sur. Missouri, Ann. Rep., p. 185, pl. B, figs. 1a-c.

Granatocrinus sayi Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 376.

Granatocrinus sayi Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 84.

Pentremites potteri Hambach, 1880: Trans. St. Louis Acad. Sci., vol. IV, p. 156, pl. B, fig. 4.

Schizoblastus sayi Ethridge & Carpenter, 1882: Ann. and Mag. Nat. Hist., vol. IX, p. 246.

Schizoblastus sayi Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 224, pl. iii, figs. 1-3.

Calyx subglobose, or ovoid; top flat. Basals small, flattened, slightly protuberant. Radials very short, somewhat wider than high, making up only about one-fourth the height of the calyx; bodies very small; limbs short; sinuses broad, with raised margins. Deltoids large, forming fully three-fourths the calyx.

Horizon and localities — Lower Carboniferous, Burlington limestone: Ash Grove (Greene county), Louisiana, Hannibal, Helton (Marion county), Palmyra (Marion county), Ste. Genevieve.

Cryptoblastus melo (OWEN & SHUMARD).

Plate xviii, figs. 7a-b.

Pentremites melo Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., vol. II, p. 65, pl. xvii, figs. 14a-c.

Pentremites melo Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 592, pl. vA, figs. 14a-c.

Elœacrinus melo Shumard, 1863: Trans. St. Louis Acad. Sci., vol. II, p. 112.

Granatocrinus melo Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 375.

Granatocrinus melo Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 84.

Schizoblastus melo Ethridge & Carpenter, 1882: Ann. and Mag. Nat. Hist., vol. ix, p. 246.

Schizoblastus melo Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 232, pl. vii, figs. 14-15.

Calyx ellipsoidal to subglobose, lobate, flattened slightly above; basal portions somewhat contracted, and excavated below; interradial areas deeply grooved in the middle. Basal plates small. Radials elongate; bodies very small; limbs long, making up more than three-fourths the calyx; sinuses extending the entire length of the calyx. Deltoids small, triangular. Ambulacra sublinear, quite convex, lying deeply in the sinuses. Surface granular.

Horizon and localities.— Lower Carboniferous, Lower Burlington limestone: Sedalia, Louisiana, Hannibal.

Cryptoblastus kirkwoodensis (SHUMARD).

Plate xvii, figs. 8a-b.

Elœacrinus kirkwoodensis Shumard, 1863: Trans. St. Louis Acad. Sci., vol. II, p. 113.

Cryptoblastus kirkwoodensis Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 144.

A form closely related to *C. melo,* but very much smaller, and with the base less deeply excavated.

Horizon and localities.—Lower Carboniferous, St. Louis limestone: Kirkwood (St. Louis county).

Granatocrinus neglectus (MEEK & WORTHEN).

Pentremites melo, var. *neglectus* Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila., p. 142.

Granatocrinus melo, var. *projectus* Shumard, 1866: Trans. St. Louis Acad. Sci., vol. II, p. 375.

Granatocrinus projectus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 496, pl. xviii, fig. 7.

Schizoblastus projectus Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 142.

Like an immature *G. norwoodi*, but is lobed, and has projecting basal parts.

Horizon and Localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana.

Granatocrinus norwoodi (Owen & Shumard).

Plate xviii, fig. 10.

Pentremites norwoodi Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., vol. I, p. 64, pl. vii, figs. 13a–c.

Pentremites norwoodi Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 591, pl. vA, figs. 13a–c.

Elœacrinus norwoodi Shumard, 1863: Trans. St. Louis Acad. Sci., vol. II, p. 112.

Granatocrinus norwoodi Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 375.

Granatocrinus norwoodi Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 465, pl. ix, figs. 2a–e.

Granatocrinus norwoodi Ethridge & Carpenter, 1886: Cat. Blastoidea, p. 245, pl. ii, figs. 34–36.

Calyx about as long as wide, somewhat pentagonal, base small, excavated. Basals very small, lying in the deep basal concavity. Radials long, nearly equaling the height of the calyx. Deltoids small, triangular. Ambulacra narrow, with parallel sides. Surface marked by small ridges and granules. Column round.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county), Palmyra (Marion county), Hannibal.

Granatocrinus curtus (Shumard).

Pentremites curtus Shumard, 1855: Geol. Sur. Missouri, 1st & 2nd Ann. Rep., pt. ii, p. 187, pl. B, figs. 3a–b.

Granatocrinus curtus Miller, 1890: N. A. Geol. and Pal., p. 250.

Similar to *G. norwoodi*, but much smaller and broader.

Horizon and localities.—Lower Carboniferous, St. Louis ? limestone: Fenton (St. Louis county).

Orophocrinus stelliformis (OWEN & SHUMARD).

Plate xvii, figs. 14a-b.

Pentremites stelliformis Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., vol. II, p. 67, pl. vii, figs. 16a-b.

Pentremites stelliformis Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 593, pl. vA, figs. 16a-b.

Orophocrinus stelliformis von Seebach, 1864: Nachr. K. Gesellsch. Wissensch., Gottingen, p. 110.

Codaster stelliformis Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 359.

Codonites stelliformis Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 84.

Codonites stelliformis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 146, pl. ix, fig. 5.

Calyx pentagonal, balloon-shaped, summit depressed, convex; cross-section deeply pentagonal; periphery almost equatorial; base narrow, expanding gradually to the basi-radial sutures, and thence rapidly to the radial lips. Basal plates forming a cup which is sometimes considerably wider than high and more or less constricted about its middle; basal sutures very short. Radial plates oblong, sides nearly parallel; bodies concave in the middle; lips much produced; interradial sutures in depressions; sinuses long and somewhat petaloid, tapering more or less at their distal ends. Deltoid pieces spearhead-shaped, constricted at about one-third of their length from the proximal ends; anal deltoid with its distal margin rounded. Ambulacra long and subpetaloid, narrowing rather suddenly at about two-thirds their length from the peristome, raised above the margins of the sinuses; lancet-plates thick, broadly lanceolate, obtusely keel-shaped in cross-section, and nearly filling the sinuses, scarcely exposed except in the median food-groove; under lancet pieces spatulate; covering pieces often in a double series and transversely elongated; side plates reaching 50 on each side of the ambulacrum, triangular in section and much bent down laterally, but almost meeting in the middle line. Spiracles more or less curved, varying in length from one-third to one-half of the ambulacra, largest at the proximal ends. Five hydrospire folds on each side of the ambulacrum. Mouth very small, the summit plates minute and polygonal. Anus oval, bounded dis-

tally by a projecting rim or margin. Top stem-joints often anchylosed together and filling the columnar cavity; column unknown. Surface marked by fine lines.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana, Sedalia, Springfield.

Orophocrinus campanulatus (HAMBACH).

Codonites campanulatus Hambach, 1884: Trans. St. Louis Acad. Sci., vol. IV, p. 553, pl. D, figs. 8-9.

Orophocrinus stelliformis var *campanulatus* Ethridge & Carpenter, 1886: Cat Blastoidea, p. 289, pl. xvi, fig. 5.

Closely related to *O. stelliformis*, and perhaps merley a varietal form. The calyx is pyriform instead of stellate.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

DOUBTFUL SPECIES OF BLASTOIDS.

Codaster gratiosus Miller, 1880: Jour. Cincinnati Soc. Nat. Hist., vol. II, p. 257.

Lower Carboniferous: Keokuk and New Bloomfield. A cast. Too imperfect for recognition.

CHAPTER VIII.

ECHINODERMS: CRINOIDS.

Although the stemmed echinoderms are among the earliest organisms, at present known, to record their existence in the rocks of the globe, their importance as types did not assume an ascendancy until toward the close of the Paleozoic. There are now living in the existing seas only a few stray forms of this once great group. In Missouri, and other parts of the broad Mississippi basin, the stalked feather-stars do not form prominent faunal features until after the Devonian. At the beginning of the Carboniferous a wide mediterranean sea occupied the heart of the American continent; and throughout its congenial waters the crinoids flourished in lavish luxuriance. It was during the deposition of these Lower Carboniferous rocks that life over the interior of North America was so remarkable for the immense development and expansion of piscine and echinodermatous types—among the latter especially for the culmination of crinoidal and blastoidal forms. Not only was the development of the Crinoidea phenomenal in the number of species, but the extensive numerical representation of individuals was most astonishing. So prolific was crinoidal life at this period, that the disjointed skeletal remains form great beds of what may be appropriately denominated a crinoidal breccia; which, however, is seldom uniform in physical characters—some layers being very hard and compact, others easily crumbling, full of interstices, and with scarcely any finer and cementing materials. Throughout are disseminated the broken and shattered calyces, fragments of arms and portions of stems. In the massive, compact beds the organic remains have been more or less completely comminuted by the grinding action of moving water. But frequently these layers are

separated by clayey or sandy seams. Here, lying partly enclosed by the hard limestone, are often myriads of stemmed feather-stars, perfect as on the day when they were entombed—forms of wondrous beauty and rare delicacy, gracefully and intricately intertwined like rich, flowing arabesques, and depicting clearly the conditions of their environment at the time when they waved slowly to and fro in the secluded depths of a great interior sea.

Composed of regular plates, definitely arranged and frequently highly ornamented, delicate arms and characteristic stems, these organisms were admirably adapted for recording all the marked changes in the physical conditions of their habitat. The testimony of the crinoids, corroborating the stratigraphic evidence, points to a slow and very gradual alteration of the sea-bottom. The long period of quietude over the broad Mississippi basin imposed especially favorable conditions of environment for a wide geographic and geologic dispersion of the various species. The great uniformity of these conditions over extended areas is amply attested by the occurrence of identical species in localities as widely separated as eastern Iowa and the Lake Valley mining region of New Mexico; or as central Illinois and the southern prolongation of the Appalachians in Alabama. But notwithstanding the extensive distribution of many species, the large majority of the Paleozoic echinoderms were limited in space and particularly in time. Those species, therefore, which experienced a wide dispersion form valuable and reliable criteria for synchronizing horizons far removed from one another. The equivalency, however, of strata of distant provinces can at best be only approximately determined from paleontological data alone. For, as has been suggested by Williams, the biologic sequence in any limited region is not indicative of the genetic succession of the inhabitants, but merely the sequence of occupants within that particular area. The gradual oscillation and change of habitat to which the Carboniferous echinoderms of the Mississippi basin were subjected would tend to make their migrations extend through longer periods of time, and their

specific existence more protracted, than the stratigraphy of any one place would indicate. And thus certain forms would become extinct in one region, and be completely replaced by very different species; while in distant localities the migratory forms would flourish in all their wonted vigor.

Echinodermatous life during the Lower Carboniferous was pre-eminently crinoidal and blastoidal—the former greatly predominating in the earlier part, and the latter conspicuously present in the later portion of the period. So marked is the contrast between the faunal features of the middle and upper portions of the Lower Carboniferous, that some writers have suggested that the Burlington and Keokuk deposits could very appropriately be called the "crinoidal" limestone; while the St. Louis and Kaskaskia are manifestly a "blastoidal" division.

In the subjoined synoptical table* are arranged the principal Carboniferous genera of the Crinoidea, and their distribution through Paleozoic time. Inasmuch as the synonymy of the species has been worked out more carefully and more accurately than in any other group of fossils, the table is especially reliable for the consideration of problems of distribution during geologic times. The figures in the various columns refer to the number of species in each genus at present known from the respective beds.

The genera enumerated in the accompanying synoptical table, while characteristically Carboniferous, are very unequally distributed in time. In nearly every instance each genus exhibits: (1) a gradual expansion after its first appearance, shown by the differentiation of the species occurring in each epoch; (2) a culmination, marked not only by a large number of species and a great numerical increase of individuals, but also by a remarkable development and specialization of the various structural characters, and by a more or less wide distribution in space; and (3) a decrease in the number of species, and a very apparent decline in physical energy,

*The abbreviations are: L. S.—Lower Silurian; U. S.—Upper Silurian; D.—Devonian; W.—Kinderhook; L. B.—Lower Burlington; U. B.—Burlington; K.—Keokuk; L.—St. Louis; C.—Kaskaskia; M.—Coal Measures.

SYNOPTICAL TABLE OF CARBONIFEROUS CRINOIDS.

Genera of Peimatozoa.	Pre-Carboniferous.			Lower Carboniferous.						U.C.
	L S.	U.S	D.	W.	L.B.	U.B.	K.	L.	C.	M.
CRINOIDEA.										
CAMERATA.										
Gilbertsocrinus	....	....	2	....	3	2	1	....	....	....
Rhodocrinus	....	....	3	3	6	2	2	1	....	....
Agaricocrinus	....	....	....	2	4	7	6	....	....	....
Alloprosallocrinus	....	....	....	....	....	....	1	....	....	....
Periechocrinus	....	3	....	..	2	1	....	....	....	....
Megistocrinus	....	....	9	2	2	1		....	....	....
Actinocrinus	....	...	....	4	21	6	5	....	....	....
Teleiocrinus	....	....	....	....	..	9	....	....	....	....
Steganocrinus	....	....	....	1	3	1	....	....	....	....
Amphoracrinus	....	....	....	1	2		....	....	....	....
Physetocrinus	....	....	....	....	2	3	...	....	....	....
Strotocrinus	....	....	....	.	.	2	....	....	....	....
Batocrinus	....	....	....	1	8	12	15	5	.	....
Eretmocrinus	....	....	....	....	7	8	5	....	....	....
Dorycrinus	....	....	1	1	5	4	3	....		....
Platycrinus	....	....	2	6	23	13	5	7	1	....
Eucladocrinus	....	....	....	....		2	....		....	....
Dichocrinus	....	....	....	2	7	6	4	2		....
Talarocrinus	....	....	....	....	....	....	....	1	4	....
Pterotocrinus	....	....	....	....	....	....	....	....	10	....
ARTICULATA.										
Ichthyocrinus	....	5	....	....	1	1	....	....	....	....
Taxocrinus	2	....	5	4	2	1	4	2		....
Forbesiocrinus	....	....	....	....	....	1	2	....	2	....
Onychocrinus	....	....	....	1	.	2	3	1	2	....
Nipterocrinus	....	....	....	....	1	1	....	....	....	....
INADUNATA.										
Larviformia.										
Allagecrinus	....	....	..	....	....	..	....	....	1	....
Symbathocrinus	....	....	1	1	2	2	1	....	..	....
Belemnocrinus	....	....	....	....	2	2	....	....	....	....
Atelestocrinus	....	....	....	....	1	1	....	....	....	....
Vasocrinus	....	....	2	....	1		1	..	....	....
Baryocrinus	....	....	....	....	2	3	15	2	...	....
Cyathocrinus	3	4	....	1	5	5	9	....	....	....
Fistulata										
Poteriocrinus	....	....	2	..	3	1	....	..	.	....
Scaphiocrinus	....	....	1	3	5	9	14	7	11	....
Scytalocrinus	....	....	..	....	..	1	4	3	5	....
Decadocrinus	....	....	5	4	2	2	2	1	2	....
Woodocrinus	....	...	1	1	1	2	3	1	....	....
Zeacrinus	....	....	....	....	1	5	1	....	6	....
Hydreionocrinus	....	....	....	....	....	....	....	....	3	5
Cromyocrinus	....	....	....	....	....	....	....	....	2	2
Eupachycrinus	...	....	..	....	....	....	....	....	4	4
Ceriocrinus	....	....	....	....	....	....	....	....	....	6
Phialocrinus	....	....	....	....	....	.	....	....	....	2
Graphiocrinus	....	....	....	....	5	2	1	....	.	2
Agassizocrinus	....	....	....	....	....	....	....	....	9	1
Calceocrinus	2	3	3	....	1	1	2	....	....	....
Catillocrinus	....	....	....	...	....	1	2	....	....	....

generally terminating in a rather abrupt extinction of the entire group.

The culmination of crinoidal life as a whole was in the middle of the Lower Carboniferous. In the great interior province, at the close of the Keokuk epoch, one-half of the Carboniferous genera had become extinct. The great group of the Camerata had passed away with the exception of the Hexacrinidæ, and a few depauperate forms of several other genera whose existence was speedily brought to a close. A large proportion of the genera in the extensive section Inadunata had disappeared; of those groups which survived to the close of the period, a diminutive species of Allagecrinus (a single specimen only being known at present) was the sole representative of the branch Larviformia; while of the great group Fistulata only the typical genus (including four subgenera) of the Poteriocrinidæ extended through the entire Lower Carboniferous. The widely distributed Calceocrinus, which began back in the Lower Silurian, became extinct just before the beginning of the Saint Louis.

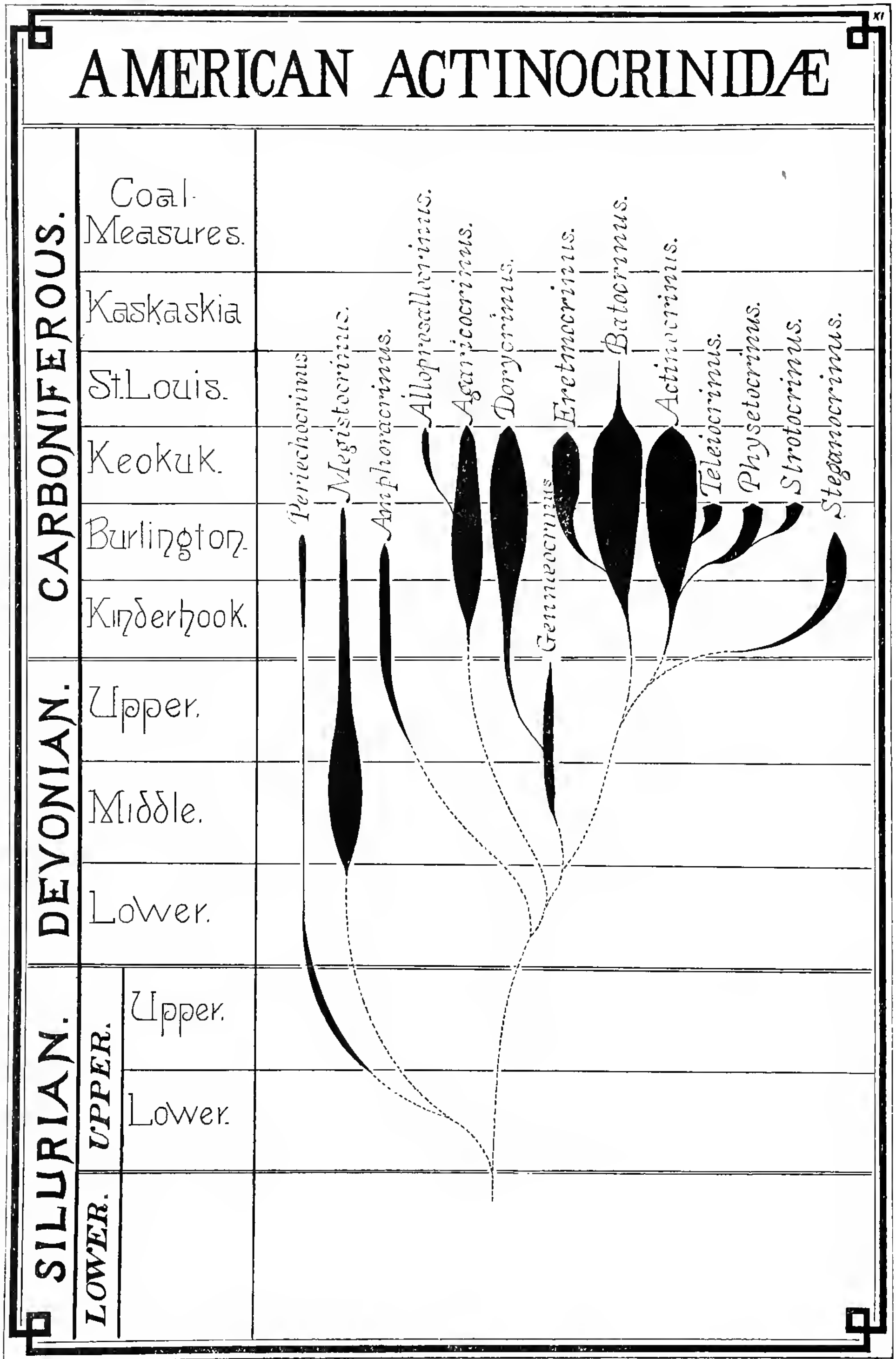
The abrupt extinction of a large proportion of the crinoidal forms toward the close of the Keokuk is certainly suggestive of a series of decided and wide-spread changes in the geographic and bathymetric extent of the great interior sea. White has already shown that at least in some portions of the Mississippi province there were very considerable alterations in the coastal contour of this broad shallow gulf, during the latter part of the Lower Carboniferous; and it is known that there were even greater changes in the coast line in other parts of this region during the same period.

Numerous attempts have been made at various times to demonstrate that in the expansion and geological development of the different groups of fossil organisms, the modification of the specific characters was very gradual, and corresponded in a striking manner with the changes of growth in the individual. Another suggestive fact is that usually the more generalized types of the various groups are the more persistent, often having a very considerable range both in time

and space. The expansion of the several families is also frequently indicated by the relatively rapid development, in the supra-generic groups, of certain structural features which soon become curiously differentiated. Perhaps nowhere in any zoological group is its culmination better or more clearly defined, in accordance with the suggestions already made, than in the Crinoidea. The remarkable multiplicity of specific and generic types appearing in rapid succession during the middle Lower Carboniferous; the extreme and phenomenal specialization of particular anatomical structures; the great increase in size, the ponderous character of the test, and the marked structural changes in many minor particulars, are all of peculiar biological significance. Toward the close of the Keokuk, nearly all of the specialized forms became extinct, and, with a few exceptions, only the more generalized types continued through the Lower Carboniferous—only such forms as were ordinally related to the living crinoids.

There is one family of the feather-stars, the Actinòcrinidæ, the most characteristic section of the group, that illustrates admirably the genetic relationships of the several generic types. In the American rocks the variety and number of these forms is indeed remarkable—perhaps nowhere equaled in any other age or region. As regards the distribution of the group in time and space, and the phylogenetic history of the camerate forms in general, many pregnant suggestions have been offered recently by certain observations made in the Mississippi valley.

More than three-fourths of the total number of the genera of the Actinocrinidæ are represented in America, distributed in time as shown in the accompanying chart (plate xi)—the relative expansion of each genus being also indicated. As compared with the ages preceding, the lower Carboniferous is here greatly exaggerated in order to show more clearly the relationships of the several zoological groups; for it was during this time that the greatest diversity of form, structure and general ornamentation occurred; in fact, it was the culmination of crinoidal life in America. Continuous lines are drawn where the record is complete and the transitions fully shown; while the



DEVELOPMENT OF ACTINOCRINUS.

dotted lines indicate the relation of the different types according to the evidence at present known, and probably coincide very closely with the real courses of divergence. The scheme is, then, to represent in a graphic way the relationship of the genera as now understood, rather than to construct a genealogical tree, with which attempts of this kind are often confounded. In the present instance, some of the earlier, more generalized forms have not been made known as yet. There are also good grounds for believing that some of the generic types are considerably older than actual observation shows. In other groups, more particularly, there is abundant evidence pointing to a much higher antiquity of the leading generic types than is generally supposed. This is especially true of many widely distributed living organisms whose ancestry has lately proved to be very ancient.

The most generalized type of the family Actinocrinidæ has dorsally a single ring of basal plates, three in number, and of equal size, succeeded by a second circle of subequal pieces, six in number—the five radials and the primary anal plate. As in all the camerate crinoids, the brachials for a considerable distance are incorporated into the calyx by means of interradial ossicles, and in the free portion of the rays they are biserial and closely interlocking. Ventrally five orals may, with a few exceptions, be made out; they are usually surrounded by a greater or less number of smaller pieces. The anal aperture may be a simple opening immediately back of the orals, or at the end of a long ventral tube. The fundamental modifications in the arrangement of the various plates give trustworthy criteria for the basis of genera; while the ornamentation, relative size and shape of the calyx ossicles form very satisfactory features for the distinction of species. The taxonomic values attached by different paleontologists to the various characters are not the same. This difference in interpretation, however, appears to arise largely from the ontogenetic history of the living forms of the class. But this diversity of opinion, happily, is rapidly lessening, with the prospect of a speedy agreement, at least in the main features, as to the relative worth of the separate structures in classification.

Before passing, however, to morphological details, it may be well to call attention to some wide-spread variations recorded. Briefly summing, then, the statements recently made in a general consideration of the most marked anatomical features displayed by the Carboniferous crinoids of the Mississippi basin, it may be said that these organisms, from the beginning of the lower Carboniferous to the close of the Keokuk, showed: (1) a wonderful and extremely varied development of the different structural characters; (2) a constant increase in size and massiveness of test; (3) a peculiar change in ornamentation, which, from the delicate style of the earlier forms, gradually grew more and more bold and rugged; and (4) many curious modifications in minor particulars.

These striking and wide-spread phenomena point to very decided changes in surroundings, such as might have resulted from a gradual decrease in the depth of the sea, a slight diminution in the density of the water, and the introduction of fine sediment in consequence of the nearer proximity to the drainage courses of the growing continent, or from marked alterations in the coastal contour of the neighboring mainland. There probably were acting also numerous other though less apparent influences. Indeed, these suggestions find substantiation in the stratigraphy of the region, which gives every reason to believe that the changes went on quietly, though at a rather rapid rate. The great abundance of individuals at this time may be due, in part at least, to the withdrawal of their more motile enemies because of the unsuitable physical impositions already mentioned. The comparatively rapid changes of environment thus imposed would force rapid modifications in the structure of the various individuals, in order to secure a more perfect adaptation to the new conditions. And when these physical changes went on with still greater rapidity, structural adjustment was unable to keep apace, and soon ended in the extinction of the group. The unfavorable conditions at a somewhat later period are further shown in the neighboring districts, where a few types still persisted, small, depauperate and few in numbers.

The Actinocrinoids are first known in the upper Silurian. They early showed signs of departure from the primitive form, and developed chiefly along two divergent lines. The one group continued to the Burlington with but slight tendencies to modification in general structure; the other soon broke up into a number of more or less well-marked sections, each of which rapidly expanded into new generic types, until about the close of the Keokuk, when, with a single exception, they became extinct. In the present connection, therefore, mention will be made of the following groups as comprising the Actinocrinidæ: Periechocrinus, Megistocrinus, Amphoracrinus, Alloprosallocrinus, Agaricocrinus, Dorycrinus, Gennæocrinus, Eretmocrinus, Batocrinus, Actinocrinus, Teliocrinus, Physetocrinus, Strotocrinus and Steganocrinus.

The general structure of the forms has already been alluded to, but some minor anatomical points in various genera may require further consideration. The first of the sections above referred to includes only two types—Periechocrinus and Megistocrinus. These genera differ from the other members of the family chiefly in the relatively large calyx, rather small branching arms, the large number of interradial plates, and in the structure of the ventral surface. In Periechocrinus the plates are smooth and thin; in Megistocrinus rather thick and more or less highly ornamented. The anal interradius has three ossicles in the second tier, with many smaller pieces in the succeeding rows.

Amphoracrinus, in the general construction of the calyx, closely approaches some forms of Agaricocrinus, but its arms are very different, resembling those of the preceding group. There are also other important distinctions. The earliest Agaricocrinus appears in the Kinderhook. At the beginning of the Keokuk a curious differentiation in some of the forms took place, giving rise to Alloprosallocrinus, of which but a single species is known as yet. The genus first mentioned is characterized by a flattened or concave dorsal region in the calyx, the free arms being given off low down on the margin of the basal plane. The rays are somewhat separated, espe-

cially on the posterior side, where a vertical row of anal plates is very noticeable. Ventrally the calyx is very protuberant, and sometimes inflated not unlike that in Amphoracrinus.

Dorycrinus is the direct lineal successor of Gennæocrinus, from which it should, perhaps, not be separated generically. The anal structure links it closely with Agaricocrinus. It differs, however, in having the general arrangement of the calyx more like Batocrinus, and in a less massive arm structure. The long spines, so conspicuous on the ventral plates of some species, seem to be merely greatly exaggerated developments, homologous with the large nodosities on similar plates in Agaricocrinus.

Extreme forms of Eretmocrinus differ from those of Batocrinus principally in the long lanceolate arms and inflated ventral parts, besides usually a more or less well-defined lateral extension of the basals. It is manifestly an offshoot of Batocrinus, for the gradations are very complete, and there is often considerable difficulty in separating the forms of the two groups. The genus was rather short-lived, appearing in the Burlington and becoming extinct before the close of the Keokuk.

In Batocrinus the long anal tube, like that of the typical form of the family, is very prominent. The arms are short. The plates in the second tier of the anal interradius are three in number; orals, large and well defined. Batocrinus is one of the most characteristic and widely-spread types of the family occurring in the Lower Carboniferous. Its relations to the other genera have already been considered elsewhere and need not be repeated here.

Actinocrinus, and the genera following, have only two pieces in the second anal tier. In the leading genus two rather well-marked sections are recognizable: one with the arms in clusters, imparting a strongly quinquelobate symmetry; the other with the arms equidistant around the margin of the calyx. The small number of brachials below the free arms is also very noticeable when compared with the four groups yet to be considered.

Teliocrinus departs from the type just mentioned in having a greater number of the lower brachials incorporated into the calyx, thus forming a more or less pronounced decagonal rim just above those of the second order. In this respect it approaches somewhat toward Strotocrinus, but the latter has a very different ventral structure.

Physetocrinus and Strotocrinus both differ from Actinocrinus in the structure of the ventral side, while the anal opening is a simple aperture in the test. The first of these types has the ventral portions of the calyx greatly elevated; the second nearly flat, while the rim is enormously developed, and the terminal free arms are not given off until the twelfth to fifteenth order of brachials.

The calyx of Steganocrinus is most like that of the lobed section of Actinocrinus, but the radial extensions are most remarkable, and give rise to a very large number of free arms.

Inasmuch as the different phases passed through during the known existence of several of the genera mentioned have been referred to already elsewhere, it is hardly necessary to take up here each group separately. It will suffice merely to consider somewhat in detail the geological history of one of the leading generic types—Actinocrinus—which will also indicate the general course of development pursued by the other members of the family.

As yet the genus Actinocrinus is not known before the beginning of the Lower Carboniferous. The forms from this horizon thus far discovered have all a more or less globular calyx, with the arms equidistantly distributed. The ornamentation has already assumed two very distinct phases. In the one, delicate ridges or small confluent nodes pass from the central portion of each dorsal plate of the calyx to the center of the adjoining ossicles; in the other, the ridges are not very conspicuous, and the plates are strongly convex on the outer surface. These two styles of sculpturing continue during the entire existence of the groups. But the first gradually loses its identity, while the second becomes greatly intensified. In

the earlier species the free arms are slender, growing much stouter in the Burlington and Keokuk, and in the latter often also branching one or more times. This development is accompanied by an increasing massiveness of the calyx plates, and a change of the simple convexity of the ossicles into great, rude nodosities. Another marked feature is the tendency of the rays to separate from one another above the second brachials, forming prominent radial extensions before giving off the free arms. At the same time the interradial areas become considerably depressed. The quinquelobate calyx is thus produced—a form upon which the genus was founded. In general it may be said that the earlier forms were of small size, delicately constructed and ornamented, and that they gradually became very much larger, more massive, with rough, rugged sculpturing.

The more striking points in the development of the anatomical features in Actinocrinus, as here briefly traced, apply to the other genera just mentioned, and also to the members of other related families. For example: Dorycrinus developed huge ventral spines; Batocrinus, an immense disk-shaped calyx; Eretmocrinus, broad, lanceolate arms; Strotocrinus, a large rim stretching out laterally from above the tertiary brachials; and Steganocrinus, monstrous radial extensions, from which the free arms sprung.

The distinctive structural characters of the genera of Actinocrinidæ and their general lines of development have already been indicated. It now remains to allude briefly to the generic relationships of the several groups. As previously stated, Periechocrinus and Megistocrinus are closely related, but they differ considerably from other members of the family. Their recorded history also extends over a much longer period than that of the other twelve genera. Periechocrinus occurs first in the Niagara—large, thin-plated forms, nearly devoid of ornamentation, and having tall, obconical calyces, with long arms branching one or more times. The evidence of this type in the American Devonian is as yet rather meager, though in Europe abundant testimony of its existence in rocks of that age is

not lacking. The forms found in the Lower Carboniferous present a somewhat different aspect from those of the earlier periods, for they have the calyx very much shortened and proportionately broadened at the base of the free arms, besides differing in several other respects.

On the other hand, Megistocrinus, with its thick, heavy plates, boldly sculptured, and having a very depressed calyx, reached its greatest development in the middle Devonian. It continued, though in greatly lessened numbers, to the upper Burlington, where it became extinct. Both genera appear to have a larger number of interradials, especially on the anal side, than any other of the Actinocrinoid groups.

Amphoracrinus approaches Agaricocrinus in the flattened dorsal cup, the high, often inflated ventral portions, and in the shape and arrangement of the plates of the aboral side. The anal side and the arms connect it with Actinocrinus and Periechocrinus: with the former by the possession of usually only two ossicles in the second tier, by the absence of the marked vertical row of anal pieces, and by the presence of a short subcentral anal tube; with the latter by the peculiar structure of the free arms.

Agaricocrinus is remarkable for the greatly depressed form of the calyx—the dorsal cup being nearly flat, or, as in some of the later species, decidedly concave. Its resemblance to Amphoracrinns has been referred to above. In the anal structure it is identical with Dorycrinus, having the same arrangement of plates, and a similar vertical, rounded ridge, near the top of which is the simple anal opening. The arms are exceedingly stout, somewhat like those in certain forms of Actinocrinus from the lower part of the Burlington limestone, but very much heavier. Agaricocrinus, Amphoracrinus and Dorycrinus probably began to diverge from the more typical members of the family, and from each other, about the same time; and this was apparently during the middle or lower Devonian. In the upper part of the Burlington or the early Keokuk a small group of forms departed still farther. These have been placed under Alloprosallocrinus, though it is doubtful whether the differences

are great enough to render a separate generic term useful. The chief point of distinction is the position of the anal opening, which is placed at the end of a short ventral tube, instead of being a simple aperture in the test, as in Agaricocrinus. It seems, however, that much more importance has been placed heretofore upon this structure in classification than it probably deserves, as will be referred to later.

Dorycrinus is directly traceable to a certain group of Devonian crinoids, for which the name Gennæocrinus has been proposed. The latter genus embraces a few small forms, mostly from the Hamilton rocks. The species of Gennæocrinus (as for example *G. cassedayi* Lyon) are connected with the Burlington and later Dorycrini by such forms as lately have been found in the Kinderhook beds of central Iowa, and which have been described as *D. immaturus* and *D. parvibasalis*. Dorycrinus, in combining the features of both, unites closely the Batocrinoid and Agaricocrinoid groups. It agrees with the first in the peculiar construction of the posterior side, in the simple anal opening, and in the radial grouping of the arms; with the second in the shape and structure of the calyx, and in the somewhat flattened distal portions of the arms, approaching certain Eretmocrini in this respect. In the earlier, more generalized forms, the close resemblance of Dorycrinus, Agaricocrinus and Eretmocrinus or Batocrinus is far more striking than in the later varieties which have become so greatly differentiated. The most prominent features, perhaps, to be noted in this connection are the monstrous ventral spines, often reaching a length of three to five inches, as in *D. mississippiensis* Roemer, and *D. roemeri* M. & W.; the immense basal expansion, as shown by *D. missouriensis* (Shumard) and *D. cornigerus* (Hall); and the stout heavy stalks with large, conspicuous nodal joints.

Actinocrinus is the type of a very remarkable group. The earlier forms bear a close resemblance to those of Batocrinus, but the possession of only two plates in the second anal tier serves readily to distinguish the two genera. As yet it has not been found to occur below the Carboniferous. It early

shows a marked tendency to differentiate along the radial lines, assuming most wonderful phases, which culminated in Teliocrinus, Strotocrinus and Steganocrinus. The more primitive forms of Actinocrinus have the free arms, as they leave the calyx, nearly at equal distances from one another; though in certain species the arms begin to show traces of separation from those of the adjoining rays. Interradial plates still further increase the distance between the clustered free-arm bases of the several rays, until finally the calyx has become strongly quinquelobate. The first section gradually diminished in numbers, and disappeared in the upper part of the Burlington; but the second continually grows more and more prominent, and ultimately attains huge dimensions before the extinction of the group.

In the upper portion of the Burlington appears a small group of crinoids—Teliocrinus—possessing all the characters of Actinocrinus, except that the lower brachials, for some distance have become larger and appear like calyx plates. These are all firmly anchylosed, and do not give off the free, biserial arms until the fifth or sixth order of brachials. The calyx thus possesses a more or less well-defined lateral extension, passing around above the brachials of the second order. This has led to the union of this group with Strotocrinus; but the rim, though very striking and very similar in each, seems to be a separate development in the two genera, rather than different stages of the same feature. In the ornamentation, the ventral structure, and the possession of a very long anal tube, the affinities of Teliocrinus are manifestly much nearer the typical representative of the family than Strotocrinus.

The Physetocrinus type begins to make its appearance in the Kinderhook, as a derivative of Actinocrinus. The earliest known divergence, perhaps, is shown best in *A. ornatissimus* W. & Spr. from the lowest member of the Lower Carboniferous. In this form the radial portions of the calyx have commenced already to become somewhat lobate, and the arms to grow longer and more slender. The plates of the ventral side are all quite small, the orals indistinguishable from the surrounding

ossicles; while the pieces around the anal tube are still smaller, indicating that this structure was very short, and in many cases probably did not project much above the ventral dome. The ornamentation of both also presents a close similarity. Some forms of *A. orpusculus* Hall from the lower part of the Burlington limestone, also show the Physetocrinus physiognomy, but in a much less marked degree. Physetocrinus appears to be the line along which Strotocrinus developed into the unique, short-lived forms which are found only in the upper part of the Burlington.

With the calyx alone under consideration, Steganocrinus would be referred immediately to Actinocrinus, but the immense, narrow, radial extensions from which spring the free arms are certainly distinctive enough for generic separation. Although in this character the genus, at first sight, departs so far from the other groups of the family, it will be seen on closer examination that the departure is only another phase of what is shown in Strotocrinus—a divergence beginning a little earlier and in a little different direction.

All through the period of their existence the Actinocrinidæ show a decided tendency to increase the distal extent of the rays. In some forms it was accomplished by the simple branching of the free arms, as in Megistocrinus, certain Amphoracrini, and a few Actinocrini; by the lateral expansion of the arms, as in Eretmocrinus; or by the radial extension of the calyx brachials, as, notably, in Teliocrinus, Strotocrinus and Steganocrinus. The number of free arms was thus increased from 20 or 30 in the earlier species of Actinocrinus, to 40 to 60 in Teliocrinus, 100 to 125 in Strotocrinus, and from 150 to 200 in Strotocrinus.

Such, then, briefly sketched, were the stemmed featherstars in their palmiest days, at a period when the present state of Missouri was covered by the congenial waters of an ancient gulf, vast, shallow, teeming with life. At no other time, within the limits of the region under consideration, were the crinoids at all conspicuous as faunal features.

On account of their great importance at the close of the Paleozoic, it is, perhaps, advisable to call attention in this place to certain anatomical structures which, in these organisms, are of prime value in classification; and especially since the nomenclature of the parts has undergone lately some radical changes, more in harmony with the results of recent morphological researches. The taxonomy is essentially that employed by Carpenter and Wachsmuth & Springer.

Forming as they do one of the great divisions of a subkingdom, the stalked echinoderms present a striking contrast to the classes most closely related. Instead of being able to move from place to place, the "stone-lilies," during life, were fixed to submerged objects by means of long, somewhat flexible stems. Only in exceptional cases were they free-swimming, as in the recent Antedon and Actinometra. Like other echinoderms, the skeletal parts of the feather-stars are made up of a great number of calcareous ossicles or plates, more or less symmetrical in outline, and definitely arranged and fitted in accordance with a fundamental plan. In general structure the ancient forms were very much like those now existing. But there are at the same time some very marked differences.

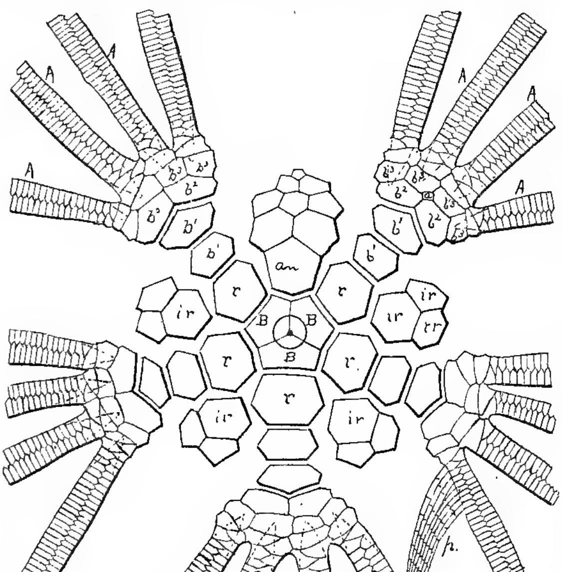


Fig 9. Plan of Actinocrinus.

A typical camerate crinoid, as for instance Actinocrinus(fig. 9), illustrates very well all the more important features. The chief modifications of

the chosen type are diagrammatically represented on plate xx, where examples of the leading crinoidal groups are shown. The crown is that portion of the crinoid without the column; while the part remaining after both stem and arms are removed is known as the calyx. The dorsal cup is the calyx below the point where the free arms are given off—the disk or tegmen being the calycinal portion ventral to the origin of the free arms. Dorsally there is a zone of basals (B, B); a ring of radials (r, r); which often, as in the case under consideration, is separated at one point, posteriorly, by the principal anal plate (An.). All radially disposed ossicles beyond the primary radials are to be regarded as brachials. For descriptive purposes it is convenient to call those brachials to the first bifurcation costals (b, b), or brachials of the first order. The plates between the first and second forkings are distichals (b^2, b^2), or brachials of the second order. If there is further dichotomizing within the calyx, there may be brachials of the third, fourth or fifth orders. The brachials not incorporated into the calyx form the free arms (A, A); which give off pinnules (p, p). Between the several rays are often one or more pieces, the interradials (ir, ir); and between the different parts of the same ray small interbrachials (a, a). Ventrally there can ordinarily be made out five orals, among a greater or less number of smaller plates.

Our knowledge of the Crinoidea has been vastly expanded through recent investigations among the ancient forms. Many interesting facts have thus been brought to light concerning the skeletal parts of these organisms. And while modern embryology furnishes much information that is important toward a complete understanding of crinoid morphology, a consideration of the extinct species is equally suggestive. A number of structures unrepresented in the living feather-stars have been disclosed in this way in all the transitional phases, so that their origin and subsequent role are capable of being traced easily. Certain anatomical features, present only for a short time in the larval forms of the modern types, were in the fossil representatives persistent through life. On the other hand, a number of characters commonly observed in the ancient spe-

cies have no analogies among the recent forms. These and other discoveries have necessitated a complete recasting of the whole systematic arrangement of the class. In the main, however, the ordinal limits probably coincide closely with the groups lately outlined by Wachsmuth & Springer, the leading authorities on this class.

The Crinoidea now appear to fall naturally into four grand divisions: (1) the Camerata, (2) the Inadunata, (3) the Articulata, and (4) the Canaliculata. The first of these sections is characterized by forms having relatively large, more or less globular calyces, near the equatorial zone of which the free arms are given off; by having comparatively short arms; by the presence of a greater or less number of interradials; and by the loss of pentamerous symmetry through the intercalation of plates on the posterior side. The ventral surface is often produced into a long anal tube, which usually extends beyond the ends of the arms.

The Camerata are almost exclusively Paleozoic forms. In sculpturing great diversity is presented, such as is nowhere else found among the feather-stars. Some species have perfectly plain surfaces; others are slightly ridged or corrugated. Many exhibit solitary nodes and simple ridges; closely related forms, rough, monstrous tubercles and bold, massive folds. A few have quaint, unique designs; while several small groups present straight, angular patterns. Still others show delicate, subdued styles of ornamentation and flowing traceries, complex and intricate. These characters, together with the numerous gracefully curved arms, fringed on either side with long, slender pinnules, and the curious flexible, knotted stems, certainly make the "stone-lilies" very attractive to scientist and layman alike.

The Inadunata embrace some of the most interesting forms of the brachiate echinoderms: those in all essential respects larval, and those closely resembling the later sedentary species. Simplicity of structure everywhere prevails, whether in the low calyx or in the long, uniserial arms. A very marked contrast do they present to the members of the

preceding group. Although never taking a prominent part in the fossil faunas, they are, from a morphological standpoint, perhaps the most important of any. And while probably none of the forms now known actually represent the larvæ of the ancient crinoids generally, some of them are certainly quite embryonal in appearance. These furnish a clue to the true explanation of many anatomical features in the other groups which have, until recently, remained enigmatical.

The third great section of the Crinoidea is a small and inconspicuous one, but nevertheless comprises many important forms, which are peculiar on account of their singular ventral structure, pliable test and non-pinnulate arms. To the fourth grand group belong most of the modern feather-stars.

Glyptocrinus fornshelli Miller.

Glyptocrinus fornshelli Miller, 1874: Cincinnati Quart. Jour. Sci., vol. I, p. 348, fig. 41.

This singular and beautiful form has been recognized in Missouri by a few single plates with their unique ornamentation.

Horizon and locality—Silurian, Hudson shales: Louisiana.

Ptychocrinus splendens (S. A. Miller).

Plate xxii, fig. 1.

Gaurocrinus splendens Miller, 1883: Jour. Cincinnati Soc. Nat. Hist., vol. VI, p. 230.

Ptychocrinus splendens Wachsmuth & Springer, 1885: Proc. Acad. Nat. Sci., Phila., p. 323.

Crown very similar to that of *Glyptocrinus*, but differing in having well-defined infrabasals. The radials and calycinal brachials have a prominent median ridge, which merges into the free arms.

Horizon and Locailty.—Lower Silurian, Trenton limestone: Cape Girardeau.

Rhodocrinus wortheni (Hall).

Rhodocrinus wortheni Hall, 1858: Geol. Iowa, vol. I, p. 556, pl. ix, figs. 8a–c.

Calyx globular, slightly flattened dorsally. Infrabasals five, small, usually covered by the stem. Basals five, rather large. Radials rather large; costals slightly smaller. Arms

rather long, slender, biserial; pinnules small. Interradials several, the largest resting on the basals. Ventral side flattened, composed of a large number of small plates; anal opening subcentral, a simple aperture. Surface of calyx plates smooth. Column round.

Horizon and localities.—Lower Carboniferous, lower Burlington limestone: Louisiana.

Rhodocrinus whitei Hall.

Rhodocrinus whitei Hall, 1861: Desc. New Species Crinoids, p. 9.
Rhodocrinus whitei Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 324.

Calyx large, depressed, spherical; ventral side elevated somewhat, with a short but prominent anal tube. Surface of the plates of the dorsal cup very convex, nearly hemispherical; smooth.

Horizon and localities.—Lower Carboniferous, lower Burlington limestone: Springfield, Louisiana.

Rhodocrinus wachsmuthi Hall.

Rhodocrinus wachsmuthi Hall, 1861: Desc. New Species Crinoids, p. 18.

Calyx very similar to *R. wortheni* but readily distinguished, among other differences, by the deep, basal concavity, which is slightly larger than the stem.

Horizon and locality—Lower Carboniferous, lower Burlington limestone: Louisiana.

Rhodocrinus coxanus Worthen.

Plate xxii, fig. 3.

Rhodocrinus coxanus Worthen, 1882: Illinois State Mus. Nat. Hist., Bul. 1, p. 30.
Rhodocrinus coxanus Worthen, 1883: Geol. Sur. Illinois, vol. VII, p. 305, pl. xxviii, fig. 7.
Rhodocrinus polydactylus Worthen, 1883: Geol. Sur. Illinois, vol. VII, p. 305, pl. xxvii, fig. 5.
Rhodocrinus parvus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 39, pl. v, figs. 8-9.

Calyx of medium size, subglobose; plates ornamented by well-defined ridges radiating from the center of each piece to the center of adjoining plates. Arms rather short, four to six to the ray.

Horizon and localities.— Lower Carboniferous, Keokuk limestone: Boonville (Cooper county); Keokuk (Iowa).

In cleaning the type specimen of Worthen's *R. coxanus,* the sculpturing has been so nearly obliterated that it escaped the notice of the draughtsman, who represented the plates as perfectly smooth.

Gilbertsocrinus typus (HALL).

Trematocrinus typus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 73.
Ollacrinus typus Wachsmuth & Springer, 1878: Proc. Acad. Nat. Sci., Phila., p. 262.
Gilbertsocrinus typus Keyes, 1889: Proc. Acad. Nat. Sci., Phila., p. 288.

Calyx very large, globose, flattened above, and extended laterally into five pairs of massive, perforated appendages. Infrabasals five, small. Basals five, rather large. Radials about as large as the basals. Costals somewhat smaller. Other calyx brachials nearly of equal size. Arms small, delicate, biserial; pinnules small. Interradials about 12 in number, the first resting on the basals. Ventral side flat, with subcentral anal opening. Plates convex or spinous as in the case of the basals and radials. Column round, small.

Horizon and localities.—Lower Carboniferous, upper Burlington limestone: Marion county. Also Burlington (Iowa).

Periechocrinus? whitei (HALL).

Actinocrinus (*Megistocrinus*) *whitei* Hall, 1861: Desc. New Species Palæ. Crinoids, p. 2.
Actinocrinus (*Megistocrinus*) *whitei* Hall, 1861: Boston Jour. Nat. Hist. vol. VII, p. 271.
Megistocrinus (*Saccocrinus*) *whitei* Meek & Worthen, 1874: Geol. Sur. Illinois, vol. V, p. 397, pl. vi, fig. 1.
Periechocrinus whitei Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 307.

Calyx large, broadly obconical, with thin, smooth plates. Otherwise much like a *Megistocrinus.*

Horizon and localities.—Lower Carboniferous, lower Burlington limestone: Hannibal.

Megistocrinus evansi (OWEN & SHUMARD).

Plate xxii, fig. 6.

Actinocrinus evansi Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila. (2), vol. I, p. 68.
Megistocrinus evansi Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin Iowa and Minnesota, p. 594, pl. vA, figs. 3a-b.

Megistocrinus plenus White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 16.

Megistocrinus parvirostris Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 165.

Megistocrinus parvirostris Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 399, pl. vi, fig. 7.

Megistocrinus evansi Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. ix, fig. 1.

Calyx very large, massive, subglobular, flattened somewhat above. Basals three, of equal size, forming a flat, hexagonal disk. Radials of medium size, slightly wider than high; first and second costals a little smaller; other calyx brachials about the same size, except toward the bases of the free arms, where they become very much shortened. Arms biserial, slender, bifurcating; pinnules long. Interradials sub-equal; anal plate like radials and in the same circlet, followed by three ossicles in the second tier. Surface of plates unornamented; usually rounded slightly at the margins. Ventral side low, flattened or slightly arched; ossicles rather large, some of them tuberculose or sub-spinous. Anal aperture opening laterally at the arm-basis. Stem long, massive, round.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Springfield.

Megistocrinus brevicornis (Hall)

Plate xxii, figs. 5a-b.

Actinocrinus brevicornis Hall, 1858: Geol. Iowa, vol. I, p. 571, pl. x, figs. 4a-b.

Actinocrinus superlatus Hall, 1858: Geol. Iowa, vol. I, p. 572.

Actinocrinus minor Hall, 1858: Geol. Iowa, vol. I, p. 573.

Megistocrinus brevicornis Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila., p. 311.

Very similar to *M. evansi*, but very much smaller, seldom attaining a measurement of the calyx of more than three-fourths of an inch, while the other species is over two inches in diameter.

Horizon and localities.— Lower Carboniferous, lower Burlington limestone: Louisiana.

Amphoracrinus divergens (Hall).

Plate xxii, fig. 4.

Actinocrinus divergens Hall, 1860: Geol. Iowa, vol. I, Supp., p. 36.
Actinocrinus planobasalis Hall, 1860: Geol. Iowa, vol. I, Supp., p. 19, pl. iv, figs. 10-11.
Actinocrinus quadrispinus White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 15.
Amphoracrinus divergens Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 388.
Amphoracrinus multiramosus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 389, pl. vi, figs. 6, 6a-c.

Calyx rather higher than wide, strongly pentalobate; dorsal cup very shallow; ventral side greatly elevated or inflated, with a short, subcentral anal tube. Column circular, with a very small axial canal. Basals three, of medium size, forming a small six-sided disk, and with a slight circular elevation around the stem juncture. Radials considerably wider than high; costals short and broad; distichals somewhat smaller. Arms stout, bifurcating. Interradials usually three in number, rather small. Orals conspicuous, bearing large spines. Surface marked by small pustules and indistinct, irregular wrinkles.

Horizon and localities.— Lower Carboniferous, lower Burlington limestone: Louisiana.

Genus Agaricocrinus Troost.

Calyx more or less distinctly pyramidal and pentalobate, usually somewhat wider than high; dorsum discoid, concave centrally; vault high, inflated, prominently nodose. Basals three, small, subequal. Radials small, hexagonal. Costals 2×5; first quadrangular, rather small; second large, broadly pentagonal; distichals large, wide; other brachials very wide, short, interlocking, the lower few more or less cuneate. Arms stout, long; pinnules slender. Dorsal interradials elongate, the first large, obovate; the two in the next row very narrow. Anal plate similar to the radials, but somewhat larger; followed by three large ossicles in the second row, and these succeeded by smaller pieces. Ventral plates large, tuberculose, central one prominent. Column round; nodal pieces larger and thicker than the others and with regularly rounded margins.

Agaricocrinus brevis (Hall).

Actinocrinus brevis Hall, 1858: Geol. Iowa, vol. I, p. 567, pl. x, figs. 3a–b.

Actinocrinus corniculus Hall, 1858: Geol. Iowa, vol. I, p. 567, pl. x, figs. 1a-c.

Agaricocrinus brevis Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 286.

Calyx rather small, depressed. Plates of the dorsal cup depressed at the angles, thus forming short ridges, which pass from one ossicle to another.

Horizon and localities.—Lower Carboniferous, lower Burlington limestone: Louisiana, Hannibal; Kinderhook (Illinois); Burlington (Iowa).

Agaricocrinus planoconvexus Hall.

Plate xxii, figs. 7a-b.

Agaricocrinus planoconvexus Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p 280.

Agaricocrinus germanus Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 42, pl. vii, figs. 8-10.

Agaricocrinus sampsoni Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 20, pl. iii, fig. 8.

Agaricocrinus blairi Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 21, pl. iii, figs. 12-15.

Agaricocrinus chouteauensis Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 43, pl. vii, figs. 11–13.

A small depressed form with smooth plates.

Horizon and localities.—Lower Carboniferous, Kinderhook limestone: Sedalia; Lower Burlington limetone: Hannibal.

Agaricocrinus pentagonus Hall.

Plate xxii, fig. 9.

Agaricocrinus pentagonus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 57.

Calyx pyramidal; dorsal cup flat, pentagonal: ventral side elevated, with nodose plates.

Horizon and localities.—Lower Carboniferous, upper Burlington limestone: Ash Grove (Greene county), Ste. Genevieve.

Agaricocrinus wortheni HALL.

Agaricocrinus wortheni Hall, 1858: Geol. Iowa, vol. I, p. 419, pl. xvi, fig. 1.

Calyx closely resembling that of *A. americanus*, from which it is most readily distinguished by the shorter radials, hexagonal, instead of quadrangular, first costals, and larger second costals.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county); Keokuk (Iowa).

Agaricocrinus americanus (ROEMER).

Plate xxii, figs. 8-ab.

Amphoracrinus americanus Roemer, 1850: Leth. Geol., vol. II, p. 250, tab. iv, fig. 15.

Agaricocrinus tuberosus Hall, 1858: Geol. Iowa, vol. I, p. 617, pl. xvi, fig. 2.

Agaricocrinus bullatus Hall, 1858: Geol. Iowa, vol. I, p. 562, pl. ix, figs. 11a-c.

Agaricocrinus excavatus Hall, 1861: Boston Jour. Nat. Hist., vol. VIII, p. 282.

Agaricocrinus americanus Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 351.

Agaricocrinus nodosus Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 167.

Agaricocrinus nodosus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 387, pl. x, fig. 7.

Agaricocrinus americanus Wachsmuth & Springer, 1885: Proc. Acad. Nat. Sci., Phila., p. 285.

Calyx pyramidal, pentalobate, wider than high; dorsal concavity large and moderately deep. Surface unmarked except the nodose plates on the oral side. Basals three, small, nearly equal in size. Radials rather small. First costals rectangular, and considerably smaller than the radials; the second much larger, pentagonal, wide; and followed by one or more somewhat smaller pieces; subsequent brachials very short, but very wide, forming a double series of interlocking plates. Arms stout, long, regularly tapering to the ends; pinnules long. Surface smooth dorsally; nodose ventrally.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county.)

Dorycrinus chouteauensis (MILLER).

Actinocrinus ? chouteauensis Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 18, pl. iii, figs. 9–11.

Like *D. kelloggi* but larger.

Horizon and localities—Lower Carboniferous, Kinderhook limestone: Sedalia.

Dorycrinus unicornis (OWEN & SHUMARD).

Plate xxiii, fig. 2.

Actinocrinus unicornis Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phil, (2), vol. II, p. 67, pl. vii, fig. 12.

Actinocrinus unicornis Owen & Shumard, 1852: Geol. Sur. Iowa, Wisconsin and Minnesota, p. 573, pl. vA, figs. 12a–b.

Actinocrinus unicornis Hall, 1858: Geol. Iowa, vol. I, p. 568, pl. x, figs. 5a–c.

Actinocrinus tricornis Hall, 1858: Geol. Iowa, vol. I, p. 569.

Actinocrinus pendens Hall, 1860: Geol. Iowa, vol. I, Supp., p. 31.

Dorycrinus unicornis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 383, pl. vi, figs. 2a–c.

Calyx subglobular, flattened below, with a long, stout, ventral spine; otherwise like Actinocrinus in the arrangement of the plates, except that there are three, instead of two ossicles, in the second anal row; and the ventral opening is a simple aperture in the disk. Arms rather stout, slightly flattened at the ends, and with broad spines directed laterally. Surface of calyx plates very convex, rounded—the nodosities developing often into almost pendant tubercles. Besides the large spine on the posterior oral, there are occasionally two smaller ones on other ventral plates directly over the postero-lateral arm-clusters.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Hannibal.

The typical species of Dorycrinus is provided with six large spines in the disk. Upon this peculiarity, principally, the genus was founded. In this particular the genus must be emended, as there are several other species manifestly belonging to the same group which have only a central spine, others three, and still others huge nodosities in place of spines. There

are, however, other characteristics which entitle Dorycrinus to rank as a valid genus.

Neither Hall, Shumard, de Koninck & Lehon, Picket nor Schultze have recognized Dorycrinus—all referring the species to Actinocrinus. It agrees with this genus only in the general family features, and in having the radial parts of the calyx more or less distinctly extended into lobes. Dorycrinus inclines far more toward Batocrinus and Eretmocrinus, with which it corresponds in the general form of the plates and in the peculiar arm structure, here becoming a constant character. It differs, however, very essentially in the usually lobate nature of the calyx, its strongly expressed bilateral symmetry, the lateral position of the anus, opening directly through the test, and in the shortness and delicacy of the arms. It is distinguished from Agaricocrinus and Amphoracrinus by the shape and proportions of the calyx, the arrangement of the plates and the altogether different arm structure. (Wachsmuth & Springer).

Dorycrinus elegans Miller.

Dorycrinus élegans Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 17, pl. iii, figs. 4-5.

A small form closely related to *D. kelloggi*, but lobes not so well defined.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia.

Dorycrinus subaculeatus (Hall).

Actinocrinus subaculeatus Hall, 1858: Geol. Iowa, vol. I, p. 570, pl. x, figs. 2a-b.

Dorycrinus subaculeatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

A small, subglobular form, very slightly pentalobate. Posterior oral produced into a prominent, sharpened nodosity, instead of the usual long spine. Surface nearly smooth, unmarked.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Dorycrinus parvus (SHUMARD).

Actinocrinus parvus Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 193, pl. A, fig. 9.

Actinocrinus trinodus Hall, 1858: Geol. Iowa, vol. I, p. 575.

Actinocrinus symmetricus Hall, 1858: Geol. Iowa, vol. I, p. 573, pl. x, fig. 8a-b.

Actinocrinus subturbinatus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 388.

Dorycrinus symmetricus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus subturbinatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus parvus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 353. (Revision, p. 179.)

Dorycrinus amœnus Miller, 1890: Geol. Sur. Missouri, Bul. 4, p. 35, pl. v, figs. 5, 6.

Calyx much like that of *D. subaculeatus*, but somewhat smaller, almost spherical, with small, sharply projecting arm lobes. Surface without ornamentation. Ventral portion hemispherical, without spines or nodes.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Palmyra, Sedalia, Ash Grove, and in St. Louis county.

Dorycrinus missouriensis (SHUMARD).

Actinocrinus missouriensis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 190, pl. A, figs. 4a-c.

Actinocrinus desideratus Hall, 1861: Boston Jour. Nat. Hist, vol. VII, p. 273.

Dorycrinus missouriensis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus desideratus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus missouriensis Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 353. (Revision, p. 179.)

Calyx higher than wide; plates thick, each marked by a central prominence; basals massive, rather high, with the lower border surrounded by a thick rounded rim, which is notched at the sutures; articular facet for the column circular slightly concave, and occupying about one-third of the diameter of the base. Radials large, as wide as long, three hexagonal and two heptagonal; upper oblique edges short, superior edges slightly concave. First costals small, not more than one-fourth as large

as the radials, quadrangular, as wide again as long, and raised in the center. Second costals pentagonal, twice as wide as high. Primary interradials rather large, as wide as long; secondary interradial pieces small, elongated, and somewhat irregular. Principal anal ossicle like the radials, but a little longer and narrower, bearing upon its upper edges three smaller pieces, and these again supporting several plates. The ventral parts have the following arrangement: Over every pair of distichals is a rather large pentagonal piece, whose inferior angle corresponds to the axis of the costals, and on each side of this plate is an elongated ossicle of irregular form, which lies over the interradials; these three pieces form the inferior segment of a circlet of seven plates, in the center of which is a large spinons or nodose plate. Near the center of the disk is a large tumid piece encircled by four orals and several other smaller plates. Surface marked only by a single large node in the center of each plate of the dorsal cup; other ossicles slightly convex, smooth.

Horizon and localities.—Lower Carboniferous; Upper Burlington limestone: Ash Grove, Palmyra, Sedalia, Hannibal and Louisiana.

The above description is somewhat abbreviated and modified from the one given originally by Dr. Shumard. The form is one of the most characteristic crinoids of the upper Burlington limestone, and is widely distributed in space. The ventral spines, as in all the spiniferous species of the genus, are seldom preserved, so that merely a large, circular tubercle is ordinarily observed.

Dorycrinus cornigerus (HALL).

Actinocrinus cornigerus Hall, 1858: Geol. Iowa, vol. I, p. 576, pl. ix, figs. 12a–c.

Actinocrinus cornigerus Hall, 1860: Geol. Iowa, vol. I, Supp. pl. iii, fig. 4.

Actinocrinus divaricatus Hall, 1860: Geol. Iowa, vol. I, Supp. p. 11.

Actinocrinus quinquelobus Hall, 1860: Geol. Iowa, vol. I, Supp. p. 15.

Dorycrinus cornigerus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus quinquelobus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Calyx of medium size, with the dorsal cup usually somewhat shorter than the calycinal part above the arm bases; very broad below, the basals often extended into a prominent flange or rim, with a concave base for the reception of the column. Ventral spines like in *D. missouriensis*, rather short, stout, but sharply pointed at the ends. Arms short and slender. Surface glabrate.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove.

Dorycrinus kelloggi Worthen.

Dorycrinus kelloggi Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 513, pl. xxix, figs. 8a-c.

A small form, with obpyramidal calyx. Ventral side flat, with nodose plates, the central one rather prominent.

Horizon and localities.— Lower Carboniferous, Keokuk limestone: Keokuk (Iowa).

Dorycrinus intermedius Meek & Worthen.

Dorycrinus quinquelobus, var. *intermedius* Meek and Worthen, 1868: Proc. Acad. Nat. Sci., Phila., p. 346.

Dorycrinus quinquelobus, var. *intermedius* Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 385, pl. x, fig. 4.

Closely resembles *D. mississippiensis* Roemer, but somewhat smaller, with fewer arms and more slender ventral spines.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Quincy (Illinois); near Burlington (Iowa).

Dorycrinus gouldi (Hall).

Plate xxiii, fig. 1.

Actinocrinus gouldi Hall, 1858: Geol. Sur. Iowa, vol. I, p. 613, pl. xv, figs. 6a-b.

Dorycrinus gouldi Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Calyx very large, massive, urceolate, strongly lobed; truncated below. Arms twenty in number. Ventral side hemispherical, provided with six long, heavy spines which are often covered with smaller spinous processes. Surface marked by large, coarse nodosities.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Curryville, Kahoka (Clark county), Boonville, La Grange; Keokuk (Iowa).

Dorycrinus mississippiensis ROEMER.

Dorycrinus mississippiensis Roemer, 1853: Archiv. fur. Naturgesch., Jahr. xix, Bund I, p. 207, tab. x, figs. 1-3.

Actinocrinus mississippiensis, var. *spiniger* Hall, 1860: Geol. Iowa, vol. I, sup., p. 54.

Dorycrinus mississippiensis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 380.

Dorycrinus mississippiensis Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 100, pl. xii, fig. 4.

Calyx like that of *D. gouldi*, but with smoother plates in the dorsal cup, and with longer spines.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Kahoka (Clark county); Keokuk (Iowa); Warsaw (Illinois).

Gennæocrinus trijugis MILLER.

Plate xxiii, figs. 3a-b.

Blairocrinus trijugis Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 69, pl. xi., figs. 1-3.

Calyx of medium size, subglobose, slightly wider than high, distinctly lobed around the periphery. Dorsal cup basin-shape, flattened below, prominently ridged toward the arms. Ventral side about as high as the dorsal, composed of rather large plates, those toward the periphery bearing short, stout spines; anal opening eccentric, at the top of a short, ventral tube. Basals three, equal, quite short. Radials rather large; costals small. Interradials numerous, continuous with those of the ventral side. Anal interradius somewhat wider than the others; the first plate similar to, and in the same circlet as, the radials; two plates in the second range, as in Actinocrinus, and smaller ossicles above. Stem circular, of medium size. Sculpturing of the dorsal cup consists of rather sharp ridges running from the center of each plate to the centers of the adjoining pieces, and thus cutting up the surface into numerous small triangular areas; the radial ridges are somewhat more pronounced than the others, and increase in size until they pass gradually into the free arms.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Gennæocrinus blends the characters of Actinocrinus, Batocrinus and Dorycrinus. The three plates in the second anal range of Batocrinus and Dorycrinus, and which are so characteristic of these genera as distinguished from the two in Actinocrinus, are in the genus under consideration sometimes present as three pieces, sometimes as only two. As regards the anal structures, a further suppression of the short tube in Gennæocrinus would produce a feature similar to that in Dorycrinus; while an extension would give the long ventral tube of Actinocrinus.

Concerning Blairocrinus, recently proposed, a glance at the type specimens shows that it is in all its details a typical Gennæocrinus. The Missouri species, however, is the first occurrence of the genus above the Devonian.

Eretmocrinus corbulis Hall.

Plate xxiii, fig. 10.

Actinocrinus corbulis Hall, 1861: Desc. New Species Palæ. Crinoids, p. 1.

Actinocrinus corbulis Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 265.

Batocrinus (*Eretmocrinus?*) *corbulis* Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 368.

Eretmocrinus corbulis Wachsmuth and Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 347.

Batocrinus comparilis Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., advance sheets, p. 32, pl. v, figs. 18-20.

Calyx somewhat like *E. calyculoides*, but much smaller and with nodose plates in the dorsal cup.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Eretmocrinus expansus Keyes.

Plate xxiii, fig. 12.

Calyx large, about as high as broad. Dorsal cup about one-half the length of the ventral side, rapidly expanding to the arm bases; basal disk low, shallow, flattened below. Ventral side greatly inflated. Surface of dorsal plates slightly convex; that of the ventral plates covered by large blunt spines and large irregular tubercles.

Horizon and localities. — Lower Carboniferous, Lower Burlington limestone: Kinderhook (Illinois).

Eretmocrinus depressus KEYES.

Plate xxiii, fig. 11.

Calyx of medium size. Dorsal cup about as high as wide; basals very large, massive, concave below, and forming a thickened projecting rim; radials about twice as wide as high; costals very small, the first quadrangular, thrice as wide as high, the second slightly larger, pentagonal. Ventral side rather low, made up of large nodose plates.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal.

Eretmocrinus carica (HALL).

Actinocrinus carica Hall, 1861: Desc. New Species Crinoids, p. 10.

Batocrinus (Eretmocrinus) carica Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368

Eretmccrinus carica Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 346.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Eretmocrinus coronatus (HALL).

Actinocrinus coronatus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 28.

Eretmocrinus coronatus Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, expl. to pl. x, figs. 8-8b.

Eretmocrinus coronatus Wachsmuth & Springer, 1881; Proc. Acad. Nat. Sci., Phila., p. 347.

Calyx small, subglobose, flattened below. Dorsal cup broad, with a wide base; plates elevated centrally. Plates of the ventral side subspinous.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Eretmocrinus leucosia (HALL).

Actinocrinus leucosia Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 261.

Eretmocrinus leucosia Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 347.

Dorycrinus confragosus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 34, pl. v, figs. 12-13.

A large stout form with very heavy, somewhat convex plates.

Horizon and locality.—Lower Carboniferous, Burlington limestone: Sedalia.

Eretmocrinus calyculoides (HALL).

Plate xxiii, fig. 13.

Actinocrinus calyculoides Hall, 1860: Geol. Iowa, vol. I, Supp. p. 17.
Batocrinus (*Eretmocrinus*) *calyculoides* Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368.
Eretmocrinus calyculoides Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 346.

Calyx of medium size, turbinate below, inflated above. Basals three in number, abont equal in size, extended below into a broad, horizontal, peripheral rim. Radials and other calyx plates as in Batocrinus. Arms very long, spatulate, and infolded. Unornamented.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove.

Eretmocrinus differs from Actinocrinns in the same way as Batocrinus—from the latter in the number and arrangement of the arms, which also have a much greater length, and a broadly spatulate form; in the form of the calyx, the extended basal rim, the preponderating ventral portions of the calyx, the eccentric position of the anal tube, its inflated character and its disposition to bend sideways. (Wachsmuth & Springer.)

Eretmocrinus verneuilianus (SHUMARD).

Plate xxiii, fig. 9.

Actinocrinus verneuilianus Shumard, 1855: Geol. Sur. Missouri, 1st and 2d Ann. Repts., pt. ii, p. 193, pl. A, figs. 1a–b.
Batocrinus (*Eretmocrinus*) *verneuilianus* Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368, pl. iv, figs. 3–4.
Eretmocrinus verneuilianus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 347.

This species has a small biturbinate calyx, with an immense, long anal tnbe. The plates have a central node.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: LaGrange, Palmyra, Helton, Hannibal, Louisiana, Ste. Genevieve, Rocheport (Boone county), Springfield, Ash Grove.

Eretmocrinus konincki (Shumard).

Actinocrinus konincki Shumard, 1855: Geol. Sur. Missouri, pt. ii, p. 194, pl. A, figs. 8a-c.
Batocrinus konincki Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.
Batocrinus (Eretmocrinus) urnæformis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368.
Actinocrinus urnæformis McChesney, 1860: New Palæ. Foss., p. 23.
Eretmocrinus konincki Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 347. (Revision p. 173.)

Calyx small, nearly twice as high as broad; dorsal cup occupying about two-thirds the height of the calyx; basal circlet high, forming a tripartite rim below. Plates extremely nodose.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county), Rocheport (Boone county), Palmyra (Marion county).

Eretmocrinus remibrachiatus (Hall).

Actinocrinus remibrachiatus Hall, 1861: Desc. New Species Crinoids, p. 11.
Actinocrinus (Eretmocrinus) remibrachiatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 370, pl. x, fig. 5.
Eretmocrinus remibrachiatus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 347.
Eretmocrinus remibrachiatus Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. ix, fig. 3.

Calyx comparatively small; dorsal cup rather low, plates smooth, basals extended into a projecting rim. Arms very long, slender, upper portions flattened, very broad.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county).

Eretmocrinus originarius Wachsmuth & Springer.

Eretmocrinus originarius Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., 1881, p. 348.
Batocrinus mediocris Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 62, pl. x, fig. 9.
Batocrinus gorbyi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 63, pl. x, fig. 10.
Batocrinus boonvillensis Miller, 1891; Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 65, pl. x, fig. 13.
Batocrinus gurleyi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 66, pl. xi, figs. 9-10.

A medium-sized form with slender arms and almost glabrate calyx.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Batocrinus æqualis (Hall).

Actinocrinus æqualis Hall, 1858: Geol. Iowa, vol. I, p. 592, pl. xi, figs. 4a-b.
Actinocrinus doris Hall, 1861: Desc. New Sp. Crinoids, p 15.
Batocrinus æqualis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.
Batocrinus doris Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 673.

Calyx subglobose, with the arms springing from the equatorial region. Basals three, of equal size. Radials large, about as high as wide; first costals quite small, quadrangular, much wider than high; second costals somewhat larger than the first, pentangular; subsequent orders of calyx-brachials about the same size as the second costals. Arms short, biserial; pinnules, slender. Anal plate like the radials and in the same circlet, with three pieces in the second row. Interradials usually about three in number, the first very much larger than the others. Ventral side hemispherical, made up of large ossicles, the orals well defined; anal tube very long, extending beyond the ends of the arms. Surface of calyx plates quite convex but not otherwise ornamented. Stem circular in cross-section; axial canal pentangular.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana, Sedalia.

Batocrinus clypeatus (Hall).

Actinocrinus clypeatus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 12, pl. iii, fig. 12.
Actinocrinus inornatus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 24.
Actinocrinus papillatus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 29, pl. iii, figs. 10-11.
Batocrinus clypeatus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 150.
Batocrinus inornatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.
Batocrinus papillatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.

Batocrinus aspratilis Miller & Gurley, 1894: Illinois State Mus. Nat. Hist., Bul. 3, p. 21, pl. v, figs. 4-6.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Batocrinus calvini Rowley.

Plate xxiii, fig. 4.

Batocrinus calvini Rowley, 1890: Am. Geologist, vol. v, p. 146, with figure.

Calyx of the *B. rotundus* type; but depressed, with spinous plates on the ventral side.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Batocrinus longirostris (Hall).

Plate xxiv, fig. 5.

Actinocrinus longirostris Hall, 1858: Geol. Iowa, vol. I, p. 589, pl. xi, figs. 2, 4c-d.

Batocrinus longirostris Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.

A globose form like *B. æqualis* (Hall), but having a higher calyx and plates less nodose.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Hannibal, Louisiana.

Batocrinus elegans (Hall).

Actinocrinus turbinatus, var. *elegans* Hall, 1858: Geol. Iowa, p. 588, pl. xi, fig. 5.

Calyx similar to that of *B. æqualis*; but the dorsal cup is much higher, and the plates composing it are less nodose or nearly smooth.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Louisiana.

Batocrinus blairi Miller.

Batocrinus blairi Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 39, pl. vi, figs. 7-9.

A subglobular, heavy-plated form with lobed arm regions.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Batocrinus æquibrachiatus (McChesney).

Actinocrinus æquibrachiatus McChesney, 1860: Desc. New Palæ. Foss., p. 25.
Actinocrinus asteriscus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 385.
Actinocrinus æquibrachiatus, var. *alatus* Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 263.
Actinocrinus asteriscus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 207, pl. xv, figs. 8a-c.
Actinocrinus æquibrachiatus McChesney, 1867: Trans. Chicago Acad. Sci., vol. I, p. 18.
Batocrinus æquibrachiatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368.

Calyx flattened, extended laterally into five broad radial lobes.

Horizon and localities. — Lower Carboniferous, Burlington limestone: White Ledge (Marion county).

Batocrinus trohiscus Meek & Worthen.

Plate xxiii, fig. 5.

Batocrinus trohiscus Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 354.
Batocrinus trohiscus Meeks & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 372, pl. v, fig. 6.

Of the type of *B. christyi*, but calyx larger, much more depressed, and very much broader.

Horizon and locality.—Lower Carboniferous, Burlington limestone: Sedalia.

Batocrinus christyi (Shumard).

Actinocrinus christyi Shumard, 1855: Geol. Sur. Missouri, pt. ii, p. 191, pl. A, fig. 3.
Batocrinus christyi Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367, pl. v, figs. 4a-b.
Batocrinus christyi Wachsmuth & Springer, 1885: Proc. Acad. Nat. Sci., Phila., pl. v, fig. 6.
Batocrinus altiusculus Miller & Gurley, 1894: Illinois State Museum Nat. Hist., Bul. 3, p. 20, pl. v, figs. 1-3.

Calyx large, turbinate; dorsal cup twice or thrice as high as ventral side; otherwise much like *B. pyriformis*, but with two arms from every opening instead of one, and the anal tube nearly smooth.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove, Rocheport (Boone county), Louisiana, Palmyra.

Batocrinus pyriformis (Shumard.)

Plate xxiii, fig. 7.

Actinocrinus pyriformis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., pt. ii, p. 192, pl. A, figs. 6a-b.
Batocrinus pyriformis Meek and Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 375, pl. v, fig. 5.
Batocrinus pyriformis Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. viii, fig. 1.

Calyx large, obpyriform; contracted and lengthened toward the basal region; ventral side somewhat inflated, with tuberculose plates; anal tube twice as long as the arms, more or less spinous.

Horizon and localities.— Lower Carboniferous, Upper Burlington limestone: Helton, Hannibal, Louisiana, Palmyra, Ash Grove.

Batocrinus laura (Hall).

Plate xxiii, fig. 8.

Actinocrinus laura Hall, 1861: Desc. New Species Crinoids, p. 15.
Batocrinus laura Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila. vol. XXXIII, p. 341.
Batocrinus scyphus Miller & Gurley, 1894: Illinois State Museum Nat. Hist., Bul. 3, p. 23, pl. v, figs. 7-9.

Like *B. rotundus* (Yandell & Shumard), but has the dorsal cup obconic in shape, and the ventral side much more depressed.

Horizon and localities.— Lower Carboniferous, Upper Burlington limestone: LaGrange; Quincy (Illinois).

Batocrinus rotundus (Yandell & Shumard).

Plate xxiii, figs. 6a-b

Actinocrinus rotundus Yandell & Shumard, 1855: Geol Sur. Missouri, Ann. Rep., pt. ii, p. 191, pl. A, figs. 2a-b.
Actinocrinus oblatus Hall, 1860: Supp. Geol. Iowa, p. 38.
Batocrinus rotundus Meek & Worthen, 1873: Geol. Sur. Illinois, vol: V, p. 367.

A sperical form with smooth plates. Arms when preserved are very short and slender.

Horizon and localities.— Lower Carboniferous, Upper Burlington limestone: Ash Grove, Sedalia, Rocheport, Hannibal, Palmyra, LaGrange; Quincy (Illinois); Bonaparte (Iowa), Burlington (Iowa).

Batocrinus subtractus (White).

Actinocrinus nashvillæ, var *subtractus* White, 1863: Proc. Boston Soc. Nat. Hist. vol. IX, p. 16.

Batocrinus nashvillæ, var. *subtractus* Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., vol. XXXIII, p. 341.

Batocrinus brittsi Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 33, pl. v, figs. 21-23.

Calyx very much smaller than in *B. nashvillæ*, and not as coarsely constructed; the ventral tube proportionally very much larger and longer, spinous.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Hannibal.

Batocrinus dodecadactylus (Meek & Worthen).

Actinocrinus dodecadactylus Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila., p. 131.

Batocrinus dodecaductylus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. II, p. 205, pl. xv, figs. 3a-c.

Calyx like *B. rotundus*, but only one-third as large, and with only twelve arms.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: White Ledge (Marion county).

Batocrinus nashvillæ (Troost.)

Actinocrinus nashvillæ Troost, 1850: Proc. Am. Ass. Adv. Sci., p. 60.

Actinocrinus nashvillæ Hall, 1858: Geol. Iowa, vol. 1, p. 609, pl. xv, fig. 4; pl. xvi, figs 4a-b

Batocrinus nashvillæ Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 368.

Batocrinus nashvillæ Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 85, pl. xiii, fig. 5.

Calyx very large, somewhat turbinate, lobed; contracted below, rapidly expanding to the arm region; ventral side drawn out into a monstrous anal tube, which, near the middle, has a ring of long, heavy spines, radiating outward, horizontally. Radials, ventral, and occasionally other, plates more or less nodose centrally.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: St. Francisville, Palmyra; Keokuk (Iowa).

Batocrinus planodiscus (HALL).

Actinocrinus planodiscus Hall, 1860: Geol. Iowa, vol. I, Supp., p. 45.
Batocrinus planodiscus Meek & Worthen, 1873: Geol. Sur Illinois, vol. V, p. 367.
Batocrinus planodiscus Wachsmuth & Springer, 1878: Proc. Acad. Nat. Sci., Phila., p. 233.

This species is very similar to *B. trohiscus*, but the calyx is very much more flattened, and extended in the region of the arm bases.

Horizon and localities. — Lower Carboniferous, Keokuk limestone: Keokuk and Bonaparte (Iowa).

Batocrinus biturbinatus (HALL).

Actinocrinus biturbinatus Hall, 1858: Geol. Iowa, vol. I, p. 616, pl. xvi, figs. 5, 6a-c.
Batocrinus biturbinatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 367.

Calyx like in *B. laura,* but with much higher ventral side.

Horizon and locality. — Lower Carboniferous, Keokuk limestone: Boonville.

Batocrinus pulchellus MILLER.

Batocrinus pulchellus Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 68, pl. xi, figs. 13-14.

Calyx small, subglobular, with slightly convex plates.

Horizon and locality.—Lower Carboniferous, Keokuk limestone: Boonville.

Batocrinus euconus (MEEK & WORTHEN).

Actinocrinus euconus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., 1860, p. 164.
Batocrinus euconus Wachsmuth & Springer, 1881: Proc. Soc. Nat. Sci., Phila., vol. XXXIII, p. 340.
Batocrinus venustus Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 67, pl. xi, figs. 11-12.
Batocrinus divalis Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 22, pl. iii, figs. 6-7.

Calyx subconic, ventral side elevated, dorsal cup low. Surface smooth.

Horizon and locality.—Lower Carboniferous, Keokuk limestone: Boonville.

Genus Actinocrinus MILLER.

Calyx top-shaped, more or less distinctly pentalobate; dorsal cup usually sculptured by prominent ridges; ventral side convex, with a long anal tube. Basals three in number, equal, flattened below. Radials very large, usually higher than wide; first costals somewhat smaller, hexagonal, about as long as wide; second costals still smaller than the first, pentagonal; distichals similar to the second costals; subsequent orders of calyx brachials variable in number, according to the number of arms; arms biserial, ranging from 20 to 60 or more, long, rather robust, with ends somewhat turned inward; pinnules long, laterally compressed; joints rather long, each armed with a hooked spine. Anal plate very large, similar to and in line with the radials, and supporting two ossicles in the second row. Interradials usually about three in number and of nearly equal size, but often followed by smaller pieces. Ventral side formed of rather large plates, some of which are somewhat nodose. Anal tube subcentral, long, stout, often extending beyond the tips of the arms. Column long, rather heavy; central canal of medium size.

Actinocrinus is one of the most important genera of the Lower Carboniferous, and is the type of a large number of forms which are more or less closely related to it.

Actinocrinus proboscidialis HALL.

Plate xxiv, fig. 1.

Actinocrinus proboscidialis Hall, 1858: Geology Iowa, vol. I, p. 584, pl. x, fig. 13.

Actinocrinus quaternarius Hall, 1860: Geol. Iowa, vol. I, Supp. p. 22.

Actinocrinus quaternarius, var. *spiniferus* Hall, 1861: Desc. New Pal. Crinoids, p. 11.

Actinocrinus themis Hall, 1861: Desc. New Pal. Crinoids, p. 11.

Actinocrinus lagina Hall, 1861: Desc. New Pal. Crinoids, p. 13.

Actinocrinus proboscidialis Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. viii, fig. 2.

Crown subcylindrical. Calyx turbinate, somewhat conical above. Column long, rather heavy, with well-defined nodal

joints; central canal circular. Basals three in number, rather large, of equal size, somewhat excavated for the reception of the stem. Radials large, slightly wider than high; costals smaller than the radial plates. Arms long, stout, with the extremities turned inward; twenty in number, equidistantly placed around the periphery of the calyx; pinnules long, compressed, with lengthened segments; the latter provided with hooked spines. Dorsal interradials subequal in size. Primary anal plate like the radials, and in the same circlet; succeeded by two ossicles in the next row. Ventral parts arched, made up of large tuberculose or subspinous pieces, with often smaller pieces intercalated. Anal tube large, extending beyond the ends of the arms. Surface ornamented by well-defined ridges radiating from the rather prominent central node on each principal dorsal plate—the radial elevations becoming more and more prominent toward the bases of the free arms. Ventral and tubal ossicles spinous.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Hannibal, Louisiana.

Actinocrinus arrosus (MILLER).

Blairocrinus arrosus Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 41, pl. vii, figs. 1-5.
Blairocrinus bullatus Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 41, pl. vii, figs. 6-7.

Horizon and localities.—Lower Carboniferous, Kinderhook beds: Sedalia.

Actinocrinus reticulatus HALL.

Actinocrinus reticulatus Hall, 1861: Desc. New Species Palæ. Crinoids, p. 2.
Actinocrinus reticulatus Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 269.

Calyx similar to that of *A. proboscidialis*, but with the dorsal cup much lower and more rounded. Ornamentation consisting of short nodes, which seldom show any indications of ridges.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Sedalia.

Actinocrinus tenuisculptus McChesney.

Actinocrinus tenuisculptus McChesney, 1859: Desc. New Species Foss. Palæ. Rocks Western States, p. 15.
Actinocrinus tenuisculptus McChesney, 1867: Trans. Chicago Acad. Sci., vol. I, pl. v, fig. 11.
Actinocrinus chloris Hall, 1861: Jour. Boston Soc. Nat. Hist, vol. VII, p. 275.

Calyx of medium size, bowl-shaped; sculpturing as in *P. ornatus* (Hall), and *St. sculptus* (Hall).

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Columbia.

Actinocrinus thalia Hall.

Actinocrinus thalia Hall, 1861: Desc. New Species Crinoids, p. 13.
Actinocrinus nodosus Miller, 1891: Bul. Geol. Sur. Missouri, No. 4, p. 33, pl. v, fig. 7.
Actinocrinus erraticus Miller & Gurley, 1894: Bul. 3, Illinois State Mus. Nat. Hist., p. 14, pl. ii, figs. 2 and 3.

Calyx rather large, arms closely arranged around the periphery. Surface highly ornamented by ridges passing from the long central node of each plate to the centers of the adjoining plates.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Actinocrinus obesus *Sp. nov.*

Plate xxiv, fig. 4.

Calyx large, broadly subfusiform; arms 20 in number, closely arranged around the periphery. Plates of the dorsal cup subspinous; those of the ventral side rather small, very numerous.

Horizon and localities—Lower Carboniferous, Burlington limestone: Hannibal.

Actinocrinus cœlatus Hall.

Actinocrinus cœlatus Hall, 1858: Geology Iowa, vol. I, p. 585, pl. x, figs. 14a–b.

Calyx similar to that of *A. proboscidialis*, but much larger and heavier.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, White Ledge (Marion county), Louisiana.

Actinocrinus fossatus Miller.

Actinocrinus fossatus Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 40, pl. vi, figs. 11-12.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia.

Actinocrinus brittsi Miller.

Actinocrinus brittsi Miller, 1892: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 56, pl. v, figs. 1-2.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia.

Actinocrinus scitulus Meek & Worthen.

Actinocrinus scitulus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 386.
Actinocrinus nesticus Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 386.
Actinocrinus sillimani Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila., p. 134.
Actinocrinus wachsmuthi White, 1861: Proc. Boston Soc. Nat. Hist., vol. IX, p. 17.
Actinocrinus scitulus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 202, pl. 15, figs. 7a-b.

Of the *A. verrucosus* type, but with small calyx; dorsal cup low and spreading. Plates of the dorsal cup ornamented by sharp nodes arising from the center of each plate.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ste. Genevieve.

Actinocrinus multiradiatus Shumard.

Actinocrinus multiradiatus Shumard 1857: Trans. St. Louis Acad. Sci., vol. I, p. 75, pl. 1, fig. 5.
Actinocrinus multiradiatus Hall, 1858: Geol. Iowa, vol. I, p. 579, pl. x, fig. 9.
Actinocrinus multiradiatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 341.
Actinocrinus multiradiatus Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. viii, fig. 3.

Calyx like *A. verrucosus* but smaller, with lower ventral side, and very different ornamentation.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county); Quincy (Illinois); Burlington (Iowa).

Actinocrinus verrucosus Hall.

Plate xxiv, fig. 3.

Actinocrinus verrucosus Hall, 1858: Geol. Iowa, vol. 1, p. 578, pl. x, figs. 7a–b.
Actinocrinus asterias McChesney, 1860: New Palæ. Foss., p. 9.
Actinocrinus asterias McChesney, 1867: Trans. Chicago. Acad. Sci., vol. I, p. 9, pl. v, fig. 6.
Actinocrinus verrucosus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 341.

Calyx somewhat urn-shaped, strongly lobed at the arm bases. Basal disk large, with thickened border, which is deeply emarginate at the sutures. Radials large, about as high as wide. Ventral side elevated, composed of large nodose plates; ventral tube long and stout. Surface of plates greatly arched or nodose; often with slight indications of rounded ridges passing from one plate to another.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Hannibal, Ash Grove (Greene county), Ste. Genevieve, and in Howard county.

Actinocrinus glans Hall.

Plate xxiv, figs. 2a-b.

Actinocrinus glans Hall, 1860: Geology Iowa, vol. I, Supp., p. 16.
Actinocrinus eryx Hall, 1861: Desc. New Palæ Crinoids, p. 12.
Actinocrinus blairi Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep, adv. sheets, p. 35, pl. v, figs. 27-29.

Calyx large, elongate-turbinate, ventral side but slightly convex, arm-openings directed upward; calyx plates smooth, slightly convex.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove.

Actinocrinus lowei Hall.

Actinocrinus lowei Hall, 1858: Geology Iowa, vol. I, p. 611, pl. xv, figs. 5a-b.

A very large, coarsely sculptured form with massive column, slender, clustered arms and strongly lobed calyx; ventral tube long, spinous.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Kahoka (Clark county); Keokuk (Iowa).

Actinocrinus lobatus Hall.

Actinocrinus lobatus Hall, 1860: Geology Iowa, vol. I, Supp., p. 51.
Actinocrinus lobatus Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 97, pl. xii, figs. 8-8a.

Like *A. lowei*, but calyx higher, more angular; ventral side elevated; plates not so tuberculose.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Kahoka (Clark county); Keokuk (Iowa); Warsaw (Illinois).

Actinocrinus jugosus Hall.

Actinocrinus jugosus Hall, 1860: Geology Iowa, vol. I, Supp., p. 49.

Closely related to *A. lowei* Hall.

Horizon and localities.— Lower Carboniferous, Keokuk limestone: Keokuk (Iowa).

Actinocrinus pernodosus Hall.

Actinocrinus pernodosus Hall, 1858: Geology Iowa, vol. I, p. 608, pl. xv, figs. 3a-b.

Another form of the *A. lowei* type.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county).

Teliocrinus umbrosus (Hall).

Actinocrinus umbrosus Hall, 1858: Geol. Iowa, vol. I, p. 590, pl. xl, figs. 3a-b.
Strotocrinus umbrosus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 190.
Actinocrinus delicatus Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 15.
Actinocrinus delicatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 243, pl. viii, fig. 2.
Strotocrinus umbrosus Meek & Worthen, 1873: Geol Sur. Illinois, vol. V, p. 360, pl. viii, fig. 5.
Teliocrinus umbrosus Wachsmuth and Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 323.
Teliocrinus umbrosus Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. viii, fig. 4.

Calyx large, somewhat urceolate, expanding above, moderately convex ventrally; above the costals extended into a very marked horizontal rim, which is formed by the anchylosed brachials up to the sixth order. Otherwise the forms of the genus are like Actinocrinus. In ornamentation the species vary considerably—some individuals showing well-defined ridges radiating from the center of each dorsal plate, others with the central nodosities large, and covering nearly the entire area of each plate.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove.

The characters above enumerated are chiefly generic. The species are distinguished from one another by their sculpturing principally. The thin, peripheral rim has led some writers to suppose that all the forms of this group are closely related to and should be united with Strotocrinus; but this view does not now appear to be the correct one. For, as satisfactorily shown by Wachsmuth & Springer, the two sections should properly be regarded as distinct generically, since in the one the long anal tube unites it with Actinocrinus, and in the other the anal opening is a mere perforation in the test. Furthermore, morphological comparisons seem to indicate that Strotocrinus was derived from Actinocrinus through Physetocrinus; while the genus under consideration was an independent off-shoot of the typical form of the family.

Teliocrinus liratus (Hall).

Plate xxiv, fig. 8.

Actinocrinus liratus Hall, 1851: Geology Iowa, vol. I, Supp., p. 4, fig. 3.
Actinocrinus subumbrosus Hall, 1861: Geology Iowa, vol. I, Supp., p. 3.
Strotocrinus liratus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. II, p. 190.
Strotocrinus liratus Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 355, pl. vii, fig. 2.
Teliocrinus liratus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 323.

This species differs from *T. umbrosus*, chiefly in the ornamentation of the calyx, which consists of a series of sharp parallel ridges passing from one plate to another, instead of mere convexities.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county).

Physetocrinus ornatus (HALL).

Plate xxiv, fig. 7.

Actinocrinus ornatus Hall, 1858: Geol. Iowa, vol. I, p. 583, pl. x, fig. 12.
Actinocrinus senarius Hall, 1860: Geol. Iowa, vol. I, Supp., p. 25.
Physetocrinus ornatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 349.
Physetocrinus ornatus Keyes, 1890: Am. Naturalist, vol. XXIV, p. 254, pl. viii, fig. 5.

Calyx like in *P. ventricosus*, but with a more depressed or nearly flat ventral surface. Plates of the dorsal cup not very convex and the ridges more continuous, forming well-defined concentric triangles.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana, Sedalia.

Physetocrinus ventricosus (HALL).

Actinocrinus ventricosus Hall, 1858: Geol. Iowa, vol. I, p. 595, pl. xi, figs. 6a-b.
Actinocrinus subventricosus McChesney, 1860: Desc. New Pal. Foss., p. 21.
Actinocrinus subventricosus McChesney, 1867: Trans. Chicago Acad. Sci, vol. I, p. 1, pl. iv, fig. 6.
Physetocrinus ventricosus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 349.

Calyx subglobose; the dorsal cup occupying about two-thirds the entire height. Ventral side very much arched, strongly lobed and folded around the margin; made up of a multitude of small ossicles which are often spinous. Anal opening a simple perforation in the test, and situated near the center of the disk. Free arms long, slender, and more or less angulated along the sides. In all other respects the arrangement of the plates is as in Actinocrinus. Surface of each piece in the dorsal cup very convex, and marked sets of three or more ribs running from the center of each plate to the adjoining ossicles, while at the corners of each plate is a small, deep, pit-like depression.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Hannibal, Sedalia.

Strotocrinus regalis (Hall).

Plate xxiv, fig. 9.

Actinocrinus regalis Hall, 1859: Geology Iowa, vol. I, Supp., p. 38.
Actinocrinus speciosus Meek & Worthen, 1860: Proc. Acad. Nat. Sci, Phila., p. 38.
Strotocrinus regalis Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 192, pl. xvi, figs. 6a–b.
Strotocrinus bloomfieldensis Miller, 1880: Jour. Cincinnati Soc. Nat. Hist., vol. II, p. 258, pl. xv, figs. 6-6a.
Strotocrinus bloomfieldensis Miller, 1881: Jour. Cincinnati Soc. Nat. Hist., vol. IV, p. 7, pl. i, fig. 6.
Strotocrinus regalis Keyes, 1890: Am Naturalist, vol. XXIV, p. 224, pl. viii, fig. 7.

Calyx very large, massive, obconic, with a broad horizontal rim around the region of the arm bases. Ventral parts flat, greatly extended laterally. Stem circular in cross-section, long, rather small, with a pentagonal central canal. Basals very large, forming a deep, truncated basin. Radials very large, hexagonal, much longer than wide. First and second costals of equal size; other brachials to the twelfth order large, firmly anchylosed to the lower pieces of the free arms for a considerable distance, and forming a wide decagonal, horizontal extension around the peripheral margin of the calyx. Tegmen composed of a large number of small, subspinous plates; with a subcentral perforation. Arms 100 to 150 in number, slender and fringed with long pinnules. Surface of the dorsal cup highly ornamented by a complex series of sharp, elevated ridges, radiating from the center of each plate to the centers of the adjoining pieces, the whole dividing the area into intricate sets of concentric triangles.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove, New Bloomfield, Hannibal.

This magnificent form is seldom found in good preservation. The crown often attains a vertical measurement of 10 or 12 centimeters and a width of even greater dimensions. There are probably but two species as yet known of this genus; though half a dozen or more specific names have been proposed for different individuals from various localities. *S. Bloomfieldensis*, described by Miller from casts found at New

Bloomfield, Missouri, is manifestly identical with *S. Regalis*, as subsequent figures of testiferous specimens well show.

Steganocrinus concinnus Shumard.

Actinocrinus concinnus Shumard, 1855: Geol. Sur. Missouri, 1st and 2nd Ann. Reps., p. 189, pl. A, fig. 5.
Actinocrinus validus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 384.
Actinocrinus concinnus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 200, pl. xv, figs. 9a-b.
Steganocrinus concinnus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 325. (Revision, p. 151.)

Calyx much larger than in *S. araneolus*, subglobose, but becoming pentalobate at the bases of the radial appendages. The sculpturing in the dorsal cup consists of a more or less well-defined node at the centers of the ossicles, each of which is connected with the nodes of the contiguous plates by a rather prominent ridge; within the triangular spaces thus formed are from one to three smaller and less noticeable concentric elevations.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Marion county, Springfield (Greene county); Kinderhook (Illinois).

Steganocrinus sculptus (Hall).

Actinocrinus sculptus Hall, 1858: Geology Iowa, vol. I, p. 582, pl. x, figs. 11a-b.
Steganocrinus sculptus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 198.

Closely resembling *S. concinnus*, but more lobate, and more highly sculptured.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: White Ledge (Marion county).

Steganocrinus araneolus (Meek & Worthen).

Actinocrinus araneolus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 387.
Steganocrinus araneolus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 198, pl. xv, fig. 1a-b.

Calyx very much broader than high, strongly pentalobate; dorsal cup nearly flat. Surface of the plates in the dorsal cup

marked by broad, angular ridges, extending from one plate to another and becoming somewhat depressed as they cross the sutures; these ribs are rendered more prominent by the excavated corners of each ossicle. Ventral pieces more or less conspicuously spinous.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Kinderhook (Illinois); Burlington (Iowa).

Steganocrinus pentagonus (Hall).

Plate xxiv, fig. 9.

Actinocrinus pentagonus Hall, 1858: Geol. Iowa, vol. I, p. 577, pl. x, figs. 6a–b.

Steganocrinus pentagonus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 198.

Steganocrinus pentagonus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 474, pl. xvi, fig. 8.

Calyx of medium size, about as broad as high, somewhat stellate, with the general arrangement of the ossicles as in Actinocrinus, but radially produced into long, slender, cylindrical extensions, from which a large number of free arms are given off. Surface of the dorsal cup ornamented by rather well-defined ridges running from the center of each plate, where they form an indistinct nodosity, to the centers of the adjoining ossicles; ventral pieces nearly smooth except toward the base of the anal tube, where they become spinous.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Platycrinus brittsi Miller.

Platycrinus brittsi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 23, pl. iii, figs. 3–4.

Calyx cup-shaped, flattened below; plates smooth; basals less than one-fourth the height of the dorsal cup; radial about as wide as high.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus ollicula Miller.

Platycrinus ollicula Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 19, pl. ii, figs. 7-8.

Calyx small, very broad at the base, slightly expanding above, with plates smooth and sutures impressed; basal disk very low, nearly as wide as the greatest breadth of calyx; radials almost rectangular.

Horizon and locality. — Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus absentivus (Miller).

Platycrinus absentivus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 15, pl. i, fig. 15.

A form closely approaching *P. pileiformis*, but much smaller and more delicate.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus æquiternus (Miller).

Platycrinus æquiternus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 14, pl. i, fig. 13.

Calyx somewhat resembling that of *P. allophylus*, but spreading more rapidly and without the annulated base.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus annosus Miller.

Platycrinus annosus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 14, pl. i, fig. 12.

Calyx like that of *P. pileiformis*, but much smaller.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus allophylus (Miller).

Platycrinus allophylus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 9, pl. i, figs. 3-4.

Calyx obconical, truncated and expanded below; basals high, with a more or less well-defined annulation around the margin of the flattened truncation; radials rather small, protuberant at the arm base; facets large; surface smooth. Stem rather stout.

Horizon and localities—Lower Carboniferous, Chouteau limestone: Sedalia.

Platycrinus discoideus Owen & Shumard.

Platycrinus discoideus Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 58, pl. vii, fig. 1.

Platycrinus discoideus Owen & Shumard, 1852: Geol. Sur. Iowa, Wisconsin and Minnesota, p. 588, pl. vA, figs. 1a–b.

Platycrinus multibrachiatus Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila., p. 134.

Platycrinus excavatus Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 286.

Platycrinus gorbyi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 15, pl. i, fig. 14.

Platycrinus pulchellus Miller, 1891: Geol. Sur. Missouri, p. 11, pl. i, fig. 7.

Platycrinus cavus Hall, 1858: Geology Iowa, vol. I, p. 527, pl. viii, figs. 1a–b.

Crown large, spreading. Calyx broad, depressed. Dorsal cup basin-shaped, very shallow; basals forming a flat, pentagonal disk, radials broad, often slightly protuberant at the arm bases. Ventral side low, hemispherical. Arms stout. Ornamentation quite variable, usually made up of nodes and granules, which frequently are confluent, forming concentric rows around the arm bases and column; arms also covered with granules and small wrinkles.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana, Sedalia.

Platycrinus discoideus is a very variable form, as may be inferred from the specific names it has received. It was one of the first species of the genus recognized in the Mississippi valley. *P. gorbyi* and *P. pulchellus*, recently described by S. A. Miller, appear to belong to Owen & Shumard's type. At Burlington, Iowa, where the original specimens were found, variations as great as is represented by these two forms are to be noted, with a complete series of intergradations.

Platycrinus subspinosus Hall.

Platycrinus subspinosus Hall, 1858: Geology Iowa, vol. I, p. 536, pl. viii., figs. 9, 10.

Platycrinus subspinosus Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 173, pl. xv, fig. 6.

Platycrinus subspinosus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 452, pl. xi, fig. 2.

Platycrinus occidentalis Miller, 1890: Geol. Sur. Missouri, Bul. 4, p. 10, pl. i, fig. 56.

The calyx of this form closely resembles that of *P. discoideus.* The basal disk, however, is smaller, the radials at the arm bases more protuberant, and the plates are usually smooth.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana, Sedalia.

Platycrinus prænuntius WACHSMUTH & SPRINGER.

Platycrinus prœnuntius Wachsmuth & Springer, 1878: Proc. Acad. Nat. Sci., Phila., p. 249, photo. pl. ii, figs. 1–2.

Platycrinus sulcatus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 16, pl. ii, fig. 2.

Calyx large, basin-shaped, composed of extremely heavy plates; basal disk deeply concave, but elevated towards the margin, which is beveled; radials wider than high, broadly beveled. Surface marked by indistinct wrinkles and nodes. Column large, heavy.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia.

Platycrinus pileiformis HALL.

Plate xxv, fig. 5.

Platycrinus pileiformis Hall, 1858: Geology Iowa, vol. I, p. 529, pl. viii, figs. 3a–c.

Platycrinus pileiformis Keyes, 1890: Proc. Acad. Nat. Sci., Phila., p. 181, pl. ii, fig. 6.

Platycrinus carchesium Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 23, pl. iii, figs, 6–7.

Calyx similar to that of *P. œqualis*, but more regularly rounded below, and columnar facet small and circular instead of large and elliptical.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Hannibal; Kinderhook (Illinois).

Platycrinus pratteni WORTHEN.

Platycrinus planus Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 57, pl. vii, fig. 4b.

Platycrinus planus Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 587 (in part), pl. vA, fig. 4b.

Platycrinus pratteni Worthen, 1860: Trans. St. Louis Acad. Sci., vol. I, p. 569.

Platycrinus planus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 469, pl. xvi, fig. 6.

Platycrinus acclivus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 12, pl. i, figs. 9–10.

Calyx large, ovoid; basals tall, nearly as high as the radials, which are slightly protuberant at the arm bases. Surface glabrate.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Platycrinus sampsoni MILLER.

Platycrinus sampsoni Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 13, pl. i, fig. 11.

Calyx large, cylindrical, rounded below: basal disk shallow; radials nearly twice as high as wide; arm facets rather small. Surface smooth.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Ash Grove (Greene county), Sedalia; Burlington (Iowa).

Miller's type is an internal cast in chert and is really too imperfect to deserve recognition. The form is, however, very characteristic and is widely distributed geographically. Specimens with the calyx preserved have been found at Burlington and elsewhere.

Platycrinus americanus OWEN & SHUMARD.

Plate xxv, figs. 2a–b.

Platycrinus americanus Owen & Shumard, 1850; Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 89, pl. xi, fig. 1.
Platycrinus americanus Owen & Shumard, 1852: Geol. Sur. Iowa, Wisconsin and Minnesota, p. 594, pl. vB, fig. 1.
Platycrinus truncatus Hall, 1858: Geology Iowa, vol. I, p. 537, fig. 59.
Platycrinus amabilis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 19, pl. ii, figs. 9–10.
Platycrinus broadheadi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 21, pl. ii, fig. 15.

A form similar to *P. burlingtonensis*, but smaller, and with the ventral side not so elevated. The sculpturing of the calyx differs greatly in different individuals; in some specimens the plates are nearly smooth; in others confluent nodes border the sutures.

Horizon and localities—Lower Carboniferous, Lower Burlington limestone: Sedalia, Louisiana, Hannibal; Kinderhook (Illinois); Burlington (Iowa).

Platycrinus burlingtonensis Owen & Shumard.

Platycrinus burlingtonensis Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 60, pl. vii, fig. 5.
Platycrinus burlingtonensis Owen & Shumard, 1852: Geol. Sur. Iowa, Wisconsin and Minnesota, p. 589, pl. vA, fig. 5.
Platycrinus exsertus Hall, 1858: Geology Iowa, vol. I, p. 589, fig. 61.
Platycrinus inornatus McChesney, 1860: Desc New Pal. Foss., p. 6.
Platycrinus burlingtonensis McChesney, 1867: Trans. Chicago Acad. Sci., vol. I, p. 9, pl. iv, fig. 3.
Platycrinus burlingtonensis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 452, pl. iii, figs. 6a–c.
Platycrinus lautus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 17, pl. 2, figs. 3-4.

Calyx small, subglobose, basal cup low; radials slightly protuberant at the arm bases; sutures impressed. Plates of the ventral side large, nodose; anal opening at the end of a small, stout tube.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia, Hannibal.

Platycrinus æqualis Hall.

Platycrinus æqualis Hall, 1861: Desc. New Species Crinoids, p. 117.
Platycrinus æqualis Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 456, pl. iii, figs. 8-8c.
Platycrinus batiola Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 22, pl. iii, figs. 1-2.

Calyx cup-shaped, regularly rounding below to the columnar facet, which is elliptical in outline and very slightly protuberant; basal portion about one-fourth the height of the dorsal cup, with sutures almost obliterated; radials slightly longer than wide, with impressed sutures.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia, Louisiana.

Platycrinus sculptus Hall.

Platycrinus sculptus Hall, 1858: Geol. Iowa, vol. I, p. 536, pl. viii, fig. 11.
Platycrinus rotundus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 20, pl. ii, figs. 11-12.

Calyx about as high as broad; regularly rounded below; basals occupying a little over one-third the height of the dorsal

cup. Ornamentation similar to *P. saffordi*, but with the tubercles covering the plates and arranged in concentric rows around the column and arm-bases.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Platycrinus halli Shumard.

Plate xxv, fig. 3.

Platycrinus planus ? Hall, 1858: Geol. Iowa, vol. I, p. 533, pl. viii, figs. 6a-b.
Platycrinus halli Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 388.
Platycrinus halli Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V. p. 454, pl. iii, figs. 3-3d.
Platycrinus acclivus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 12, pl. i, figs. 9-10.

Calyx large, subglobose, heavy; basal cup bowl-shaped, with columnar scar circular; radials a little higher than wide; ventral side hemispherical, composed of large, heavy plates which are convex externally; arms 12 to 16 to the ray. Surface smooth, or occasionally with indistinct folds or obtuse ridges.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county); Burlington (Iowa).

Platycrinus bonoensis White.

Platycrinus bonoensis White, 1879: Proc. Acad. Nat. Sci., Phila., p. 30.
Platycrinus bonoensis White, 1883: U. S Geol. & Geog. Sur. Terr., 12 Ann. Rep., p. 160, pl. xl, fig. 5a.
Platycrinus æternalis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 11, pl. i, fig. 8.

A small form with smooth, bowl-shaped calyx, stout arms, six to the ray, and heavy stem.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Platycrinus boonvillensis Miller.

Platycrinus boonvillensis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 8, pl. i, figs. 7-8.

Much like *P. halli* apparently, but with the radials somewhat wider than high.

Horizon and locality.—Lower Carboniferous, Keokuk limestone: Boonville.

Platycrinus saffordi Troost.

Plate xxv, fig. 1.

Platycrinus saffordi Troost, MS.
Platycrinus saffordi Hall, 1858: Geol. Iowa, vol. I, p. 634, pl. xviii, figs. 5-6.

Calyx of medium size, urn-shaped, truncated below; basal cup high, nearly one-half the height of the dorsal cup; surface smooth, with a row of prominent pustules bordering the sutures on each plate, and on the radials running from the lower corners to the arm bases; in this triangular space are frequently several more or less distinct horizontal rows of tubercles. Ventral side moderately elevated.

Horizon and localities — Lower Carboniferous, Keokuk limestone: Wayland (Clark county); Warsaw (Illinois).

Platycrinus saræ Hall.

Platycrinus saræ Hall, 1858: Geology Iowa, vol. I, p. 673, pl. xviii, fig. 4.
Platycrinus saræ Shumard, 1865: Trans. St. Louis Acad. Sci., vol. II, p. 390.

Calyx subglobose; surface smooth; arms long, rather slender, six to the ray.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Eucladocrinus pleuroviminus (White).

Platycrinus discoideus Hall, 1858: Geol. Iowa, vol. I, p. 535, pl. viii, figs. 8a-b (not Owen & Shumard, 1850).
Platycrinus pleuroviminus White, 1863: Proc. Boston Soc. Nat. Hist., vol. IX, p. 17.
Platycrinus (*Eucladocrinus*) *pleuroviminus* Meek, 1870: Am. Jour. Sci.
Eucladocrinus pleuroviminus Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 251.

Calyx large, massive, basin-shaped, and in all respects as in Platycrinus. Surface ornamented by coarse wrinkles.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove, Sedalia, Hannibal.

Usually only the calyx or scattered calycinal plates are found, and therefore the true distinction between this form and Platycrinus is not apparent. Instead, however, of having a small number of arms springing in clusters from each radial, there are long radial extensions, bordered on each side by many arms, as in Steganocrinus.

Dichocrinus lineatus Meek & Worthen.

Dichocrinus lineatus Meek & Worthen, 1869: Proc. Acad. Nat. Sci, Phila., p. 69.

Dichocrinus lineatus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 440, pl. iii, fig. 1.

Similar to *D. striatus*, but smaller, and with much finer sculpturing.

Horizon and localities—Lower Carboniferous, Lower Burlington limestone: Hannibal, Louisiana.

Dichocrinus liratus Hall.

Dichocrinus liratus Hall, 1861: Desc. New Species Crinoids, p. 5.

Dichocrinus liratus Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 290.

Calyx of medium size, with broad, shallow basal cup; radials with a rather prominent angularity running from the lower angles on each side to the base of the free arms. Surface otherwise smooth.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove (Greene county).

Dichocrinus striatus Owen & Shumard.

Plate xxv, fig. 8.

Dichocrinus striatus Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 62, pl. vii, fig. 10.

Dichocrinus striatus Owen & Shumard, 1852: U.S. Geol. Sur. Iowa, Wisconsin and Minnesota, p. 590, pl. vA, fig. 10.

Calyx rather above medium size, subglobose. Surface ornamented by large rounded ridges running longitudinally from the base to the top of the radials.

Horizon and localities.—Lower Carboniferous, Upper Burlington limestone: Ash Grove.

Dichocrinus ficus Casseday & Lyon.

Dichocrinus ficus Casseday & Lyon, 1860: Proc. Am. Acad. Arts and Sci., vol. V, p. 24.

Dichocrinus ficus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 500, pl. xiv, fig. 2.

Dichocrinus coxanus Worthen, 1882: Illinois State Mus. Nat. Hist., Bul. 1, p. 35.

Dichocrinus coxanus Worthen, 1883: Geol. Sur. Illinois, vol. VII, p. 313, pl. xxvii, fig. 7.

Dichocrinus parvulus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 27, pl. iv, figs. 7-8.

Dichocrinus humbergi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 26, pl. iii, figs. 9-10.

Dichocrinus humbergi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 36, pl. vi, fig. 38.

Calyx higher than wide, somewhat conical. Basals two in number, of equal size, forming about one-half of the dorsal cup. Radials very large, oblong, with well-defined articular facet, for the support of the brachials, which occupies about one-half the width; costals very small, the second supporting two arms. Arms slender, biserial; pinnules long and stout, two to the ray. Anal plate very large, similar to the radials and in the same circlet. Ventral side flattened. Surface of plates smooth. Stem circular.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville; Keokuk (Iowa).

The species of Dichocrinus are readily mistaken for those of Platycrinus, but may easily be distinguished by having two basal pieces instead of three, as in the latter genus, and in having six large plates in the second circlet instead of five. In most of the species of this genus rarely more than the dorsal cup, or the anchylosed basals, are found, and hence the group usually escapes the notice of the majority of collectors. *D. ficus* seems to be a rather widely distributed species and admits of considerable variation throughout its range. It was first described from Indiana by Casseday and Lyon in 1860; and since that time has been recognized in several other localities where the Keokuk rocks are exposed. *D. coxanus* of Worthen

appears to be the same form, though the figure given in the Illinois report is somewhat faulty. S. A. Miller's recently described *D. parvulus* also seems to be identical with Casseday & Lyon's form.

Dichocrinus blairi Miller.

Plate xxv, fig. 7.

Dichocrinus blairi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 36, pl. viii, fig. 12.

Closely related to *D. ficus*, but with four arms to the ray instead of only two.

Horizon and locality. — Lower Carboniferous, Keokuk limestone: Boonville.

Talarocrinus simplex (Shumard).

Plate xxv, fig. 6.

Dichocrinus simplex Shumard, 1857: Trans. St. Louis Acad. Sci., vol. I, p. 74, pl. i, figs. 2a-b.

Dichocrinus simplex Hall, 1858: Geology Iowa, vol. I, p. 654, pl. xxiii, figs. 12a-b.

Dichocrinus simplex Wachsmuth & Springer, 1881: Proc. Acad. Nat. Sci., Phila., p. 258.

Dorsal cup small, ovoid, smooth externally, and almost indistinguishable from that of a Dichocrinus. Other parts as yet unknown.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Ste. Mary.

Although only the dorsal cup of this species is known, other forms have been described showing that in the ventral structure Talarocrinus is very different from Dichocrinus. In the first genus the ventral side is very high, composed of relatively large plates which are often spiniferous, and the anal opening is a mere aperture in the test. In the second group the calyx above the radials is low, the plates small and the ventral aperture at the end of a short elevation.

Pterotocrinus chesterensis (MEEK & WORTHEN).

Dichocrinus (Pterotocrinus) chesterensis Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 383.

Pterotocrinus chesterensis Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 292, pl. xxiii, figs. 1a-c.

Dorsal cup basin-shaped, about twice as broad as high, expanding very rapidly from the base to the arm region; basals two in number, large, concave below; radials about twice as wide as high, slightly convex. Brachials of the first, second and third orders resting on the upper edge of the radials. Anal plate long, nearly as wide as the radials. Arms four to the ray.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Symbathocrinus wortheni HALL.

Plate xxv, fig. 15.

Symbathocrinus wortheni Hall, 1858: Geology Iowa, vol. I, p. 560, pl. ix, fig. 9.

Calyx small, obconic, truncated dorsally. Basals three in number, forming a low cup. Radials five, large, quadrangular. Arms very long, slender, composed of quadrangular plates arranged in single rows—the five together forming a long tube. Anal plate small, much longer than wide. Stem small, slender, round.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Springfield, Hannibal.

Symbathocrinus dentatus OWEN & SHUMARD.

Plate xxv, fig. 14.

Symbathocrinus dentatus Owen & Shumard, 1852: Jour. Acad. Nat. Sci., Phila., (2), vol. II, p. 93, pl. xi, fig. 7.

Symbathocrinus dentatus Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 597, pl. vB, figs. 7a-b.

Very much like *S. wortheni,* but much larger and more robust.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Columbia, Springfield, Ste. Genevieve.

Symbathocrinus swallovi HALL.

Symbathocrinus swallovi Hall, 1858: Geology Iowa, vol. I, p. 672, pl. xvii, figs. 8-9.
Symbathocrinus blairi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 32, pl. iv, figs. 13-15.

Like *S. dentatus*, but more angular in the back of the arms.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: St. Louis county, Boonville; Keokuk (Iowa).

Belemnocrinus? sampsoni MILLER.

Plate xxv, fig. 9.

Belemnocrinus sampsoni Miller, 1890: Geol. Sur. Missouri, Bul. 4, p. 26, pl. iii, fig. 8.

Dorsal cup small, thrice as high as wide. Basals large, very long and narrow. Radials about two-thirds as high as basals, subquadrangular. Arms two to the ray, with the bifurcation on the fourth brachial. Column of medium size, round.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Sedalia.

Parisocrinus intermedius (HALL).

Cyathocrinus intermedius Hall, 1858: Geology Iowa, vol. I, p. 627, pl. xviii, fig. 10.
Parisocrinus intermedius Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila., (Revision, p. 115).

This form unites the genera Cyathocrinus, with which it agrees in arm structure and manner of articulation, and Poteriocrinus.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Warsaw (Illinois).

Cyathocrinus iowensis OWEN & SHUMARD.

Plate xvx, fig. 11.

Cyathocrinus iowensis Owen & Shumard, 1850; Jour. Acad. Nat. Sci., Phila. (2), vol. II, p. 63.
Cyathocrinus iowensis Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 591, pl. 5A, figs. 11a-c.
Cyathocrinus malvaceus Hall, 1858: Geol. Iowa, vol. I, p. 554, pl. ix, fig. 5.
Cyathocrinus divaricatus Hall, 1861: Jour. Boston Soc. Nat. Hist., vol. VII, p. 299.

Cyathocrinus viminalis Hall, 1861: Jour. Boston Soc. Nat. Hist., vol. VII, p. 299.

Cyathocrinus sampsoni Miller, 1891: Geol. Sur. Missouri, Bul. No. 4, p. 30, pl. iv, figs. 9-10.

Calyx sub-globose, flattened above; sutures impressed; infrabasals five, rather large, curving slightly upward. Basals very large, the posterior broadly truncated. Radials also somewhat larger than the basals, with large articulating facets. Arms long, slender, bifurcating. Anal plate above medium size. Ventral side closed by five large ossicles. Stem round.

Horizon and localities—Lower Carboniferous, Burlington limestone: Louisiana, Sedalia.

Cyathocrinus boonvillensis Miller.

Cyathocrinus boonvillensis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 29, pl. iv, figs. 3-4.

Calyx globular, ornamented by double ridges passing from the center of one plate to the adjoining plates. Arms stout.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Cyathocrinus enormis Meek & Worthen.

Plate xxv, fig. 12.

Poteriocrinus enormis Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., 1865, p. 137.

Cyathocrinus enormis Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., 1865, p. 152.

Calyx like *C. iowensis,* but thinner and more conical.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal.

Lecythiocrinus olliculæformis White.

Plate xxv, fig. 13.

Lecythiocrinus olliculæformis White, 1880: Proc. U. S. Nat. Mus., vol. II, p. 257, pl. i, figs. 4-5.

Lecythiocrinus olliculæformis White, 1883: U. S. Geol. Sur. Terr., 12th Ann. Rep., p. 124, pl. xxxv, figs. 2a and 6.

Lecythiocrinus adamsi Worthen, 1882: Illinois State Mus. Nat. Hist., Bul. 1, p. 37.

Lecythiocrinus adamsi Worthen, 1883: Geol. Sur. Illinois, vol. VII, p. 317, pl. xxxi, figs. 8a-d.

Calyx subovoid, somewhat higher than wide; plates thin; infrabasals small; basals very large, much longer than wide; radials about two-thirds the size of the basals, with small articular facets. Surface smooth.

Horizon and localities. — Carboniferous, Upper Coal Measures: Kansas City.

Barycrinus spurius (Hall).

Cyathocrinus spurius Hall, 1858: Geology Iowa, vol. I, p. 625, pl. xviii, figs. 7, 8.

Barycrinus spurius Meek & Worthen, 1868: Proc. Acad. Nat. Sci., Phila., p. 340.

Barycrinus spurius Worthen, 1890: Geol. Sur. Illinois, vol. VIII, p. 99, pl. xiv, fig. 4.

Calyx cup-shaped, with massive plates, which are convex, and depressed at the corners. Infrabasals five in number, rather small, and together forming a small pentagonal disk, which is nearly hidden by the heavy column. Basals very large. Radials a little larger than the basals, unequal in size; articulating facets large, concave, and facing obliquely outward. Anal plates two, the lower one very small.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Wayland (Clark county); Keokuk (Iowa).

Barycrinus hoveyi (Hall).

Cyathocrinus hoveyi Hall, 1861: Jour. Boston Soc. Nat. Hist, vol. VII, p. 293.

Barycrinus hoveyi Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 486, pl. xiii, fig. 1.

Barycrinus blairi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 25, pl. iii, figs. 11-13.

Calyx similar to that of *B. spurius*, but with the depressions along the longitudinal sutures more pronounced. Arms of medium length, rather slender, two to the ray usually, though occasionally again branching.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville; Keokuk (Iowa).

Barycrinus stellatus (Troost).

Cyathocrinus stellatus Troost, MS.
Cyathocrinus stellatus Hall, 1858: Geol. Iowa, vol. I, p. 623, pl. xvi, figs. 3–8.
Cyathocrinus quinquelobus Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., p. 150.
Cyathocrinus quinquelobus Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 519, pl. xx, figs. 6a-b.
Barycrinus stellatus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 103.)

Like *B. spurius*, but with large nodosities on the basal plates.

Horizon and localities. — Lower Carboniferous, Keokuk limestone: Boonville, Curryville (Pike county); Keokuk (Iowa).

Barycrinus rhombiferus (Owen & Shumard).

Poteriocrinus rhombiferus Owen & Shumard, 1850: Jour. Acad. Nat. Sci., Phila., (2), vol. II.
Poteriocrinus rhombiferus Owen & Shumard, 1852: U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 595, pl. 5B, figs. 2a-c.
Barycrinus rhombiferus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 103.)

A small, obconical form with the sutural depressions very marked.

Horizon and localities —Lower Carboniferous, Burlington limestone: Louisiana.

Barycrinus magnificus Meek & Worthen.

Plate xxvi, fig. 4.

Barycrinus magnificus Meek & Worthen, 1868: Proc. Acad. Nat. Sci., Phila., p. 340.
Barycrinus magnificus Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 483, pl. xii, figs. 2a-b.

Calyx very large, often having a diametric measurement of five or six centimeters; massive. Surface covered with small tubercles.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Keokuk (Iowa).

Barycrinus meekianus (Shumard).

Poteriocrinus meekianus Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 188, pl. A, figs, 7a-b.

Calyx similar to *B. spurius.*

Horizon and localities.—Lower Carboniferous, Burlington limestone: Mount Vernon.

Poteriocrinus brittsi Miller.

Poteriocrinus brittsi Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 30, pl. iv, figs. 5-6.

Poteriocrinus ognatus Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 43, pl. viii, figs. 6-7.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Scaphiocrinus missouriensis (Shumard).

Plate xxvi, fig. 2.

Poteriocrinus longidactylus Shumard, 1855: Geol. Sur. Missouri, Ann. Rept., p. 188, pl. B, figs. 5a-c.

Poteriocrinus missouriensis Shumard, 1857: Trans. Acad. Sci., St. Louis, vol. I, p. 80.

Poteriocrinus missouriensis Hall, 1858: Geology Iowa, vol. I, p. 669, pl. xvii, figs. 7a-b.

Poteriocrinus (*Scaphiocrinus*) *missouriensis* Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 114.)

Dorsal cup small, obconical; infrabasals large, nearly equaling the basals in size; radials wider than high. Arms very long, slender, bifurcating once, twice or even more times; composed of slightly wedge-shaped pieces. Ventral side very similar to that of Poteriocrinus. Column circular in cross-section, often slightly angular near the calyx.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Scaphiocrinus dactyliformis Hall.

Scaphiocrinus dactyliformis Hall, 1858: Geology Iowa, vol. I, p. 670, pl. xvii, fig. 6.

As compared with *D. missouriensis* the calyx is much lower, angular, and with three arms to the ray.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Scaphiocrinus rusticellus (White).

Plate xxvi, fig. 1.

Poteriocrinus rusticellus White, 1863: Boston Jour. Nat. Hist., p. 505.
Scaphiocrinus rusticellus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 113).

Calyx very small, ridged. Arms rather large, very long, with stout pinnules.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Hannibal; Burlington (Iowa).

Scaphiocrinus proboscidialis (Worthen).

Poteriocrinus proboscidialis Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 518, pl. xxxi, fig. 1.
Scaphiocrinus proboscidialis Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 114).

Similar to *S. missouriensis,* but more robust; calyx much smaller. Arms bifurcating on the third brachial and again on the seventh to tenth.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Carondelet (Saint Louis county).

Scaphiocrinus scoparius Hall.

Scaphiocrinus scoparius Hall, 1858: Geology Iowa, vol. I, p. 680, pl. xxv, fig. 3.

A very small form, with a relatively large, smooth calyx, short, stout arms and large pinnules.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Scaphiocrinus? boonvillensis Miller.

Scaphiocrinus boonvillensis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 37, pl. v, figs. 1-2.
Scaphiocrinus constrictus? Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 38, pl. v, figs. 3-4.

A small form, resembling *S. rusticellus*, but rather stouter.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Scaphiocrinus? sampsoni MILLER.

Scaphiocrinus sampsoni Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., advance sheets, p. 46, pl. ix, fig. 12.

A rather small form of the *S. missouriensis* type.

Horizon and locality.—Lower Carboniferous, Chouteau limestone: Sedalia.

Scaphiocrinus? gorbyi MILLER.

Scaphiocrinus gorbyi Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 46, pl. xii, fig. 15.

Horizon and localities—Lower Carboniferous, Keokuk limestone: Boonville.

Scytalocrinus vanhornei (WORTHEN).

Plate xxvi, fig. 3.

Poteriocrinus vanhornei Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 517, pl. xxxi, figs. 2, 3.
Scytalocrinus vanhornei Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 118).

Crown slender, cylindrical. Dorsal cup obconic; infrabasals large; radials about as large as infrabasals, truncated above. Brachials of the first order two, or sometimes only one; arms simple, two to each ray, except the anterior, which has only one, long, slender, rather stout, and made up of somewhat wedge-shaped ossicles; pinnules rather long. Ventral tube cylindrical. Column pentagonal near the calyx, but gradually becoming circular below.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Scytalocrinus dactylus (HALL).

Graphocrinus dactylus Hall, 1860: Geology Iowa, vol. I, Supp., p. 89.
Scytalocrinus dactylus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 117).

Basals elongated, quite broad. Surface granulose.

Horizon and localities—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Woodocrinus elegans (Hall).

Plate xxvi, fig. 5.

Zeacrinus elegans Hall, 1858: Geology Iowa, vol. I, p. 547, pl. ix, figs. 1-2.
Zeacrinus troostianus Meek & Worthen, 1860: Proc. Acad. Nat. Sci., Phila., p. 390.
Zeacrinus scoparius Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 305.
Zeacrinus sacculus White, 1862: Proc. Boston Soc. Nat. Hist., vol. IX, p. 12.
Zeacrinus elegans Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 128).
Woodocrinus elegans Wachsmuth & Springer, 1886: Proc. Acad. Nat. Sci., Phila., p. 166.
Zeacrinus commaticus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 36, pl. v, figs. 10-11.

Crown elongate-pyriform. Dorsal cup shallow, basin-shaped, with a rounded concavity for the reception of the stem, and occupied by the infrabasals; basals relatively large. Anal side similar to Poteriocrinus. Radials rather large. Arms bifurcating, broad, flattened outwardly, and closely appressing one another; arm-plates short, very wide, rectangular. Column small, circular in cross-section.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Woodocrinus pocillum (Miller)

Zeacrinus pocillum Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 28, pl. iv, figs. 1-2.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Boonville.

Zeacrinus magnoliæformis (Owen & Shumard).

Cyathocrinus magnoliæformis Owen & Shumard, 1846: Researches Carb. Rocks Kentucky.
Zeacrinus magnoliæformis Troost, 1850: Cat. Crinoids Tennessee.
Zeacrinus magnoliæformis Hall, 1858: Geology Iowa, vol. I, p. 684.

Very similar to certain species of Woodocrinus, but has much smaller infrabasals and basals and much larger radials.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Hydreionocrinus acanthophorus (Meek & Worthen).

Plate xxvi, fig. 6.

Zeacrinus (Hydreionocrinus ?) acanthophorus Meek & Worthen, 1870: Proc. Acad. Nat. Sci., Phila., p. 28.
Zeacrinus (Hydreionocrinus ?) acanthophorus Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 563, pl, xxiv, figs. 11a-h.
Hydreionocrinus acanthophorus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 131).

Crown subcylindrical. Dorsal cup very short, basin-shaped, concave below; infrabasal disk small, hidden by the column; basals five, rather small, four of them of eqnal size, the fifth somewhat smaller than the others, longer, and slightly curved at the end, which is truncated for the support of one of the anal pieces; radials rather large, much wider above than below, strongly curved, straight along the upper edge. First brachials somewhat smaller than the radials, pentagonal. Arms rather slender, bifurcating on the second plate. Plates of the anal side arranged as in Woodocrinus. Ventral sac about equaling the length of the arms, relatively narrow, but gradually widening upward, until near the top it abruptly spreads out horizontally to about the greatest width of the calyx; the upper surface is flat, composed of nnmerous small polygonal pieces, and bordered by a dozen or more large, flattened ossicles, which bear long, heavy spines directed outward all around. Surface of calyx smooth. Stem small.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Hydreionocrinus pentagonus Miller & Gurley.

Hydreionocrinus pentagonus Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 17, pl. ii, figs. 6 7.

Dorsal cup similar to *H. acanthophorus*, but basal concavity rather deeper and pentagonal in shape.

Horizon and locality.—Upper Carboniferous, Upper Coal measures: Kansas City.

Hydreionocrinus mucrospinus (McChesney).

Zeacrinus mucrospinus McChesney, 1859: Desc. New Pal. Foss, p. 10.

Zeacrinus mucrospinus McChesney, 1867: Trans. Chicago Acad. Sci., vol. I, p. 7, pl. iv, fig. 7.

Hydreionocrinus mucrospinus Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 131).

The Missouri specimens are known only from loose plates.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Cromyocrinus globosus (Worthen).

Agassizocrinus globosus Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 557, pl. xxi, figs. 1–4.

Cromyocrinus globosus Wachsmuth & Springer, 1886: Proc. Acad. Nat. Sci., Phila., p. 248.

Calyx globose, plates heavy; infrabasals large. Anal opening toward the upper end of a short ventral protuberance. Otherwise much like Eupachycrinus.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Cromyocrinus buttsi (Miller & Gurley).

Ulocrinus buttsi Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 7, pl. i, figs. 5-6. (Reprint, p. 7).

Calyx large, somewhat higher than broad; plates heavy, convex, granulose.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Cromyocrinus kansasensis (Miller & Gurley).

Plate xxiv, fig. 7.

Ulocrinus kansasensis Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 8, pl. i, figs. 7-10. (Reprint, p. 8.)

Calyx subglobose; infrabasals large, extending beyond the border of the column, forming a low saucer-shaped disk, slightly concave centrally, for the reception of the column; basals about as high as wide, three of them hexagonal, the two posterior ones heptagonal, slightly larger; radials not quite so large as the basals, the lateral faces very short; the right pos-

terior radial somewhat distorted by the azygous plate, which is large, quadrangular, obliquely set, and with the upper angle slightly truncated for the first plate of the ventral sac. Column circular.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Eupachycrinus maniformis (YANDELL & SHUMARD).

Cyathocrinus maniformis Yandell & Shumard, 1847: Cont. Geol. Kentucky, p. 22, pl. i, fig. 2.
Poteriocrinus maniformis Shumard, 1855: Geol. Sur. Missouri, Ann. Rept., p. 217.
Zeacrinus maniformis Hall, 1858: Geol. Iowa, vol. I, p. 682, pl. xxv, fig. 8.
Scytalocrinus maniformis Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 117).
Eupachycrinus maniformis Wachsmuth & Springer, 1886: Proc. Acad. Nat. Sci., Phila., p. 173.

Calyx small, globular, much as in *C. globosus* in general appearance. Arms ten in number, very stout.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Eupachycrinus orbicularis (HALL).

Scaphiocrinus orbicularis Hall, 1861: Boston Jour. Nat. Hist., vol. VII, p. 311.
Eupachycrinus orbicularis Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila.
Eupachycrinus orbicularis Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 97, pl. xiv, figs. 2-2a.

Calyx globular, greatly depressed; plates smooth.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Keokuk (Iowa); Hamilton (Illinois).

Eupachycrinus verrucosus (WHITE & ST. JOHN).

Plate xxvii, fig. 2.

Hydreionocrinus verrucosus White & St. John, 1869: Trans. Chicago Acad. Sci., vol. I, p. 117.
Eupachycrinus verrucosus Meek, 1872: U. S. Geol. Sur. Nebraska, p. 151, figs. 3, 4a-d.

Calyx large, depressed, hemispherical, with infrabasal parts concave; plates heavy, more or less convex, strongly beveled

along the margins, and covered with large, prominent tubercles. Infrabasals five, forming a rather small, flattened pentagonal disc, of which about one-third is hidden by the column. Basals large, strongly curved, about as high as wide. Radials twice as wide as high, about the size of the basals; articulating surface broad, flat. First anal plate quadrangular, about one-half the size of the basals upon which it rests; second anal plate not quite so large, and resting upon the first anal piece and one of the basals and between the two radials; it is pentagonal in shape. Surface ornamented by numerous large nodose elevations and microscopic granulations.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Eupachycrinus? harii Miller.

Plate xxviii, fig. 3.

Eupachycrinus harii Miller, 1891: Geol. Sur. Indiana, 17th Ann. Rep., adv. sheets, p. 71, pl. xi, fig. 8.

Calyx twice as wide as high, with plates of the dorsal cup convex and smooth or granular. Arms 18 in number.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Eupachycrinus magister Miller & Gurley.

Plate xxvii, figs. 1a-b and 3.

Eupachycrinus magister Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 4, pl. i, figs. 1–2. (Reprint.)
Eupachycrinus sphæralis Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 5, pl. i, figs. 3–4. (Reprint.)

This form is more closely related to *E. verrucosus* than to any other species, from which it differs chiefly in having more intricate sculpturing, and in the smaller and concave infrabasal circlet of plates.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Phialocrinus harii (MILLER & GURLEY).

Plate xxix, fig. 1.

Æsiocrinus harii Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 16, pl. iii, fig. 1.

Phialocrinus harii Carpenter, 1891: Ann. and Mag. Nat. Hist., July, 1891, p. 96.

Like *P. magnificus,* but arms more slender and ventral sac much smaller.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Phialocrinus stillativus (WHITE).

Plate xxviii, figs. 6a-b.

Cyathocrinus stillativus White, 1880: Proc. Nat. Mus., vol. I, p. 258, pl. i, figs. 9–10.

Dorsal cup shallow, basin-shaped, depressed dorsally for the reception of the column; plates rather thin, strongly convex, often somewhat angular, instead of rounded, and deeply depressed at the corners; radials nearly twice as wide as high, the articular facets facing outward. Anal plate rather small, resting on the broadly truncated end of the posterior basal and supporting two plates in the second range, which also abut against the radials for nearly one-half of their height.

Horizon and localities —Upper Carboniferous, Upper Coal Measures: Kansas City.

While the arrangement of the plates in the dorsal cup is precisely the same as in Phialocrinus, with perhaps the exception that the second range of anal plates lies partly within the dorsal cup, and rests against the radials, this form, along with some others, has comparatively thin plates.

Phialocrinus carbonarius (MEEK & WORTHEN).

Poteriocrinus (Scaphiocrinus?) carbonarius Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila., p. 140.

Scaphiocrinus carbonarius Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 562, pl. xxiv, figs. 2a-c.

Graphiocrinus carbonarius Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 123.)

A very small form. Dorsal cup basin-shaped, two and one-half times wider than high, with plates very convex, and much depressed at the corners.

Horizon and localities. — Upper Carboniferous, Upper Coal Measures: Kansas City.

Phialocrinus barydactylus (sp. nov)

Plate xxviii, fig. 1.

Crown like in ***P. harii***, but with only a single arm to the ray as a rule, and very robust as compared with those of the species mentioned.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Phialocrinus magnificus (MILLER & GURLEY).

Plate xxviii, fig. 4.

Æsiocrinus magnificus Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist.,vol. XIII, p. 15, pl. ii, figs. 1-5.

Phialocrinus magnificus Carpenter, 1891: Ann. and Mag. Nat. Hist., July, 1891, p. 96.

Calyx rather small, subglobose, smooth, closely related to Ceriocrinus. Arms very long, slender, ten in number. Ventral sac very long, highly ornamented.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Phialocrinus basiliscus (MILLER & GURLEY).

Æsiocrinus basiliscus Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 53, pl. ix, figs. 4-6.

Very closely related to ***P. magnificus***, but with a greater number of arms.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Ceriocrinus hemisphericus (SHUMARD).

Plate xxviii, figs. 2 and 5

Poteriocrinus hemisphericus Shumard, 1865: Trans. St. Louis Acad. Sci., vol. I, p. 221. (Not *P. hemisphericus* Miller, 1856.)

Scaphiocrinus hemisphericus Meek & Worthen, 1875: Geol. Sur. Illinois, vol. V, p. 561, pl. xxiv, fig. 1.

Scaphiocrinus ? hemisphericus Meek, 1872: U. S Geol. Sur. Nebraka, p. 147, pl. v, fig. 1.
Ceriocrinus hemisphericus Wachsmuth & Springer, 1886: Proc. Acad. Nat. Sci., Phila., p. 254.
Delocrinus hemisphericus Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. —, pl. ii, figs. 8-9. (Reprint, p. 12.)
Delocrinus missouriensis Miller & Gurley, 1890: Jour. Cincinnati Soc. Nat. Hist., vol. XIII, p. 9, pl. ii, figs. 11-13. (Reprint.)

Calyx small, smooth, basin-shaped; and differing from an Eupachycrinus in having but a single azygous plate.

Horizon and locality.—Upper Carboniferous, Upper Coal Measures: Lexington, Columbia (Boone County), Kansas City.

Agassizocrinus dactyliformis Troost.

Agassizocrinus dactyliformis Troost, 1850: Proc. Am. Ass. Ad. Sci., p. 60.
Agassizocrinus dactyliformis Shumard, 1853: Marcy's Rep. Red. River of Louisiana, p. 199.
Agassizocrinus dactyliformis Hall, 1858: Geol. Iowa, vol. I, p. 685, fig. 113.

Calyx obconical, with curved sides. Infrabasals large, heavy, firmly united. Basals large; radials small, wider than high. Posterior side as in Cromyocrinus in the arrangement of the plates.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Edriocrinus pocilliformis Hall.

Plate xxx, fig. 7.

Edriocrinus pocilliformis Hall, 1859: Pal. N. Y., vol. III, p. 121, pl. v, figs. 8-12.
Edriocrinus pocilliformis Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 370, pl. vii, figs. 5a-b.

Dorsal cup obconical; base slightly wider than high, rounded below and a little oblique, faintly scalloped above. Radials slightly longer than the base, longer than wide. Anal plate somewhat narrower than the radials. Surface smooth.

Horizon and localities.—Upper Silurian, Lower Helderberg ? limestone: Bailey's Landing (Perry county).

Calceocrinus ventricosus (Hall).

Cheirocrinus ventricosus Hall, 1860: 13th Reg. Rep. New York State Cab. Nat. Hist., p. 123.

Cheirocrinus dactylus Hall, 1860: 13th Reg. Rep. New York State Cab. Nat. Hist., p. 123.

Cheirocrinus nodosus Hall, 1860: 13th Reg. Rep. New York State Cab. Nat. Hist., p. 123.

Calceocrinus dactylus Shumard, 1866: Trans. St. Louis Acad. Sci., vol. II, p. 358.

Calceocrinus ventricosus Shumard, 1866: Trans. St. Louis Acad. Sci., vol. II, p. 359.

Cheirocrinus wachsmuthi Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 74.

Calyx small, compressed, slightly longer than wide, a little concave in the middle of the dorsal side. Base somewhat trigonal, twice as wide as high. Radials four in number, very irregular, the two longer ones occupying about three-fourths of the anterior side of the calyx and supporting two small brachials; the two smaller radials are also quite irregular. Arms composed of simple joints.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Calceocrinus tunicatus (Hall).

Plate xxx, fig. 4.

Cheirocrinus tunicatus Hall, 1860: 13th Reg. Rep. New York State Cab. Nat. Hist., p. 124.

Calceocrinus tunicatus Shumard, 1866: Trans. St. Louis Acad. Sci., vol. II, p. 359.

Calceocrinus robustus Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 92, pl. xii, fig. 7.

Calceocrinus tunicatus Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 93, pl. xii, fig. 6.

Closely related to *C. ventricosus*, but much larger and heavier.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Keokuk (Iowa).

Ichthyocrinus burlingtonensis HALL.

Ichthyocrinus burlingtonensis Hall, 1858: Geology Iowa, vol. I, p. 557.

Crown pyriform, with small basin-shaped dorsal cup. Infrabasals rudimentary; basals five, very small; first, second and third orders of brachials similar and rapidly widening upwards. Arms closely pressed together, infolded at the ends.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Louisiana.

Taxocrinus thiemi (HALL).

Plate xxx, fig. 5.

Forbesiocrinus thiemi Hall, 1861: Boston Jour. Nat. Hist, vol. VII, p. 317.

Much smaller than *T. giddingei.*

Horizon and locality.—Lower Carboniferous, Lower Burlington limestone: Hannibal.

Taxocrinus giddingei (HALL).

Forbesiocrinus giddingei Hall, 1858: Geology Iowa, vol. I, p. 633, pl. xvii, figs. 2, 4.

Taxocrinus giddingei Wachsmuth & Springer, 1879: Proc. Acad. Nat. Sci., Phila. (Revision, p. 48.)

Forbesiocrinus elegantulus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 40, pl. v, figs. 14–15.

Crown rather short and stout. Infrabasals very small, almost covered by the stem. Basals five, four of which are about equal in size, with sharp, superior angles, the fifth larger and truncated on the upper side. Radials rather large. Brachials of the first order, usually three in number, sometimes four, rectangular; bifurcations usually three in number; arm plates small, quadrangular. Interradial plates variable in number; resting on the truncated upper angle of the posterior is a vertical row of eight or more quadrangular plates, united to the rays by smaller pieces, which are rarely observable.

Horizon and localities.— Lower Carboniferous, Keokuk limestone: Boonville.

Taxocrinus shumardianus (HALL).

Forbesiocrinus shumardianus Hall, 1858: Geology Iowa, vol. I, p. 671, pl. xvii, fig. 1.

Taxocrinus shumardianus Wachsmuth & Springer, 1879: Proc Acad. Nat. Sci., Phila. (Revision, p. 49.)

This species differs from *T. giddingei* in being stouter, and in having relatively much shorter arms.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Forbesiocrinus agassizi HALL.

Plate xxx, fig. 3.

Forbesiocrinus agassizi Hall, 1858: Geology Iowa, vol. I, p. 631.

Forbesiocrinus agassizi Hall, 1860: Geology Iowa, vol. I, Supp., p. 65.

Forbesiocrinus agassizi, var. *giganteus* Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 495, pl. xviii, fig. 3.

Calyx large, composed of large, convex, smooth plates. Arms long, slender, infolded at the ends for a considerable distance. Interradials numerous. Anal interradials scarcely different from the others.

Horizon and localities—Lower Carboniferous, Burlington limestone: Burlington (Iowa).

Forbesiocrinus wortheni HALL.

Forbesiocrinus wortheni Hall, 1858: Geology Iowa, vol. I, p. 632, pl. xvii, fig. 5.

Somewhat smaller than *F. agassizi*, and with the interradial areas more depressed.

Horizon and localities. — Lower Carboniferous, Keokuk limestone: Keokuk (Iowa), Bonaparte (Iowa).

Onychocrinus monroensis (MEEK & WORTHEN).

Plate xxx, fig. 2.

Forbesiocrinus monroensis Meek & Worthen, 1861: Proc. Acad. Nat. Sci., Phila. p. 130.

Onychocrinus monroensis Meek & Worthen, 1866: Geol. Sur. Illinois, vol. II, p. 244, pl. XVII, fig. 7.

Crown rather below medium size, prominently divided into five rays. Infrabasals scarcely visible beyond the margin of the column. Basals five, the posterior truncated on the upper

angle, for the support of the anal row of plates, much as in Taxocrinus. Radials large; rays becoming free at the second brachial. Arms short, stout, branching several times. Interradials few—the lower one large and resting on the upper sloping sides of the radials, with two pieces in the second range; column stout, tapering gradually downward, composed of very thin ossicles.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Spurious and Doubtful Species.

Glyptocrinus fimbriatus Shumard, 1855: Geol Sur. Missouri, Ann. Rep., p. 194, pl. A, figs. 10a-b. Girardeau limestone (Trenton), Cape Girardeau county. Not a Glyptocrinus.

Platycrinus pentagonus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 16, pl. ii, fig. 1. Keokuk limestone, Boonville.

Platycrinus blairi Miller, 1891: Geol Sur. Missouri, Bul. 4, p. 21, pl. ii, figs. 13-14. Burlington limestone, Sedalia.

Platycrinus baticola Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 22, pl. iii, figs. 1-2. Burlington limestone, Sedalia.

Platycrinus concinnus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 18, pl. ii, figs. 5-6. Burlington limestone, Sedalia.

Platycrinus chouteauensis Miller, 1891: Geol. Sur Indiana, 18th Ann. Rep., adv. sheets, p. 14, pl. ii, figs. 14-15. Kinderhook limestone, Sedalia.

Platycrinus colletti Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep., adv. sheets, p. 14, pl. ii, fig. 16-17. Kinderhook limestone, Sedalia.

Barycrinus boonvillensis Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 24, pl. iii, fig. 5. Keokuk limestone, Boonville.

Missouricrinus admonitus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 31, pl. iv, figs. 11-12. Burlington limestone, Sedalia.

Poteriocrinus? rugosus Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 223. Coal Measures, Putnam county. Cannot be recognized.

Scaphiocrinus boonvillensus Miller, 1891: Geol. Sur. Missouri, Bul. 4, p. 37, pl. v, figs. 1-2. Keokuk limestone, Boonville.

Scaphiocrinus constrictus Miller, 1891: Geol. Sur. Missouri, Bul. No. 4, p. 38, pl. v, figs. 3-4. Keokuk limestone, Boonville.

Actinocrinus sedaliensis Miller, 1892: Geol. Sur. Indiana, 18th Ann. Rep adv. sheets, p. 16, pl. iii, fig. 1-3. Burlington limestone, Sedalia.

CHAPTER IX.

CRUSTACEANS.

Lichas boltoni (BIGSBY).

Paradoxides boltoni Bigsby, 1825: Jour. Acad. Nat. Sci., Phila., vol. IV, p. 362.

Paradoxides boltoni Green, 1832: Monog. Trilobites North America, p. 60, pl. i, fig. 5.

Paradoxides boltoni Harlan, 1834: Trans. Geol. Soc. Pennsylvania, vol. I, p. 103.

Platynatus boltoni Conrad, 1838: Ann. Rep. Palæ. New York, p. 118.

Actinurus boltoni Castleman, 1843: Syst. Sil. de l'Amerique Sept., p. 21, t. v, fig. 3.

Lichas boltoni Hall, 1852: Palæ. New York, vol. II, p. 311, pl. lxx, figs. 1a-i.

Lichas boltoni Meek & Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 503, pl, xxv, fig. 5.

Pygidium oval, wider than long, deeply serrate behind. Median lobe narrow, furrows deep; lateral lobes broad, flat. Surface thickly covered with granules.

Horizon and localities.—Upper Silurian, Niagara? limestone: Grafton (Illinois); also, Pike county?

Illænus graftonensis MEEK & WORTHEN.

Illœnus (Bumastus) graftonensis Meek & Worthen, 1869: Proc. Acad. Nat. Sci., Phila., p. 54.

Illœnus (Bumastus) graftonensis Meek & Worthen, 1875: Geol. Sur. Illinois, vol. VI, p. 508, pl. xxv, fig. 4.

Cephalic shield like in *I. insignis,* but much broader, elliptic; eyes small.

Horizon and localities.—Upper Silurian, Niagara? limestone: Grafton (Illinois).

Illænus insignis? Hall.

Plate xxxii, figs. 1a-b.

Illænus insignis Hall, 1864: Advance sheets New York State Cab. Nat. Hist., 20th Rept., p. 27.

Illænus insignis Hall, 1868: New York State Cab. Nat. Hist., 20th Rept. p. 331, pl. xxii, figs. 13-14.

Illænus insignis Meek, 1873: Geol. Sur. Ohio, Palæ., vol. I, p. 189, pl. xv, figs. 5a-c.

Illænus insignis Whitfield, 1882: Geol. Sur. Wisconsin, vol. IV, p. 305, pl. xxi, figs. 6-10.

Illænus insignis Foerste, 1886: Geol. and Nat. Hist. Sur. Minnesota, 15th Ann. Rept., p. 481.

Large, elliptical. Cephalic shield moderately convex, widest behind the middle; posterior margin nearly straight; marginal border narrow. Glabella rather strongly convex; dorsal sinuses well defined. Facial sutures extending forward from each eye with a distinct outward curve. Movable cheeks sloping off rapidly on each side. Eyes large. Pygidium considerably larger than head-piece. Surface smooth.

Horizon and localities.—Upper Silurian, Niagara? limestone: Pike and St. Louis counties.

Acidaspis hamata? (Conrad).

Discranurus hamata Conrad, 1841: 5th Ann. Rep. N. Y. Geol. Sur., p. 48, pl. 1, fig. 1.

Discranurus hamata Hall, 1862: 15th Rep. N. Y. State Cab. Nat. Hist., pl. ii, fig. 1.

Acidaspis hamata Hall, 1859: Pal. New York, vol. III, p. 371, pl. lxxix, figs. 15-19.

Acidaspis hamata Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 290, pl. vii, fig. 17.

Only fragmentary remains supposed to be closely related to, if not identical with Conrad's species are known from Missouri.

Horizon and localities.—Upper Silurian limestone: Bailey's Landing (Perry county).

Cyphaspis girardeauensis Shumard.

Plate xxiv, fig. 2.

Cyphaspis girardeauensis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep. p. 197, pl. B, figs. 11a–b.

Ovate, depressed. Cephalic shield semicircular, forming more than one-third the length of the body, very moderately convex; exterior border raised, narrow, prolonged posteriorly into slender curved spines, which extend back to the seventh thoracic segment; within the border is a narrow well-defined groove, and between this and the furrow which passes round in front of the glabella is a slightly raised surface. Glabella subovate, rounded in front, truncated behind, and occupying rather more than two-thirds the length of the head; greatest width a little in advance of the middle; surface moderately convex and but little elevated above the cheeks; at the base on either side is a small ovate tube, about half the length of the glabella, and entirely separated from it by a narrow, deeply impressed groove; longitudinal furrows narrow, profound, uniting in front of the glabella; occipital furrow straight, narrow, deep; occipital annulation about as high as the glabella, wide in the middle, narrowing toward the extremities, with a small central tubercle. Cheeks depressed, convex; eyes small, nearly circular, situated close to the glabella and opposite to the anterior half of its lateral lobes. Thorax with ten segments, with strongly marked longitudinal furrows; median lobes wider than the lateral lobes, slightly flattened in the middle, rings slightly arched toward the front, separated by strong furrows; seventh segment provided with a long slender spine extending backward beyond the posterior margin of the pygidium. Tail piece semicircular, twice as wide as long; border narrow; axial lobe with about seven segments. Surface glabrate.

Horizon and localities.—Upper Silurian, Girardeau limestone: Cape Girardeau.

Encrinurus deltoideus Shumard.

Encrinurus deltoideus Shumard, 1855: Geol. Sur. Missouri, Ann. Rept., p. 198, pl. B, fig. 10.

Encrinurus [*Cryptonynus*] *deltoideus* Vogdes, 1879: Mon. Genera Zethus, etc., p. 21.

Encrinurus deltoideus Foerste, 1887: Bul. Dennison Univ., vol. II, p. 102.

Tail piece triangular, moderately convex, broadly curved in front, rather sharply rounded behind. Median lobe separated from the lateral lobes by deep furrows; segments rather narrow, about twenty-four in number, all but the first five somewhat blended above; lateral lobes considerably wider than the middle one; annulations eight, rather narrow at the origin, but widening rapidly outward, and curving backward and downward; surface apparently smooth, though covered with microscopic granules.

Horizon and localities.—Upper Silurian, Girardeau limestone: Cape Girardeau.

Dalmanites tridentifera (Shumard).

Plate xxxii, figs. 3a-b.

Dalmania tridentifera Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 199, pl. B, figs. 8a-c.

Dalmanites tridentifera Meek & Worthen, 1868: Geol. Sur. Illinois, vol. III, p. 391, pl. vii, fig. 16.

Cephalic shield rather low; border rather wide, elevated a little, with a broad shallow furrow running parallel to it nearly the entire length; front extended into a conspicuous three-pronged process, the ends of which are turned upward slightly. Glabella moderately arched; frontal lobe wider than long, oval, or subrhomboid; dorsal sinus rather deep. Eyes very large, lunate. Pygidium moderately convex, produced behind into a short spinous process; median lobe made up of about four annulations; the lateral portions of about ten.

Horizon and localities.—Upper Silurian, Delthyris shaly limestone: Bailey Landing (Perry county), Birmingham (Cape Girardeau county).

Acidaspis halli SHUMARD.

Plate xxxii, fig. 4.

Acidaspis halli Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 200, pl. B, figs. 7a, b, c.

Small; glabella moderately convex, somewhat wider than long; frontal border somewhat elevated, with the posterior limiting furrow rather deep, and ornamented by a row of large granules; dorsal sinuses deep; median portion raised somewhat above the lateral lobes, with a broad frontal lobe which occupies about one-fourth the entire length; occipital sinus well defined, though rather shallow. Fixed cheeks narrow. Movable cheeks of medium size, with well-marked border, produced behind into a rather long, somewhat curved spine; margin with about 14 short, spinous processes, those in front quite short, those behind five or six times as long as the anterior ones. Thoracic segments with the axial portion considerably narrower than the lateral lobes, which are produced into long stout spines. Pygidium small, with the median portion made up of two annulations; lateral lobes rather flattened, with a single distinct ridge, which broadens toward the margin of the last piece and extends into a long curved spine on each side.

Horizon and localities.—Lower Silurian, Cape Girardeau limestone: Cape Girardeau.

Calymene senaria CONRAD.

Calymene senaria Conrad, 1841: Ann. Rept. Geol. New York, p. 44.

Calymene senaria Hall, 1847: Palæ. New York, vol. I, p. 238, pl. lxiv, figs. 2a-n.

Calymene senaria Meek, 1875: Geol. Sur. Ohio, Palæ. vol. I, p. 173, pl. xiv, figs. 14a-f.

Subovate, length about one and one-half times the breadth, height rather more than one-third the breadth.

Cephalic shield as seen in a direct view from above sub-semi-circular, approaching sublunate, the anterior outline being more or less nearly regularly rounded, and the posterior broadly sinuous, with the posterior lateral extremities bluntly sub-angular, or abruptly rounded. Glabella more prominent than the cheeks or eyes, about as wide behind as its length, including

the neck segment, very strongly defined from the cheeks and the front margin (which latter is very prominent, and strongly recurved and arched upward in the middle) by profound furrows; lateral lobes, particularly the two posterior pairs, distinctly defined by deep lateral furrows that curve a little backward, the posterior pair being transversally or obliquely a little oval and about three times as large as those of the next pair, which are as much larger than the third pair, all being nearly round; neck furrow well defined, neck segment about of the same size as the first thoracic segment, often slightly thickened at each end, arched a little forward, and nearly or quite as high as the most prominent part of the glabella in front. Eyes rather prominent, small, nearly surrounded, excepting on the inner side, by a shallow concavity, and situated opposite the furrows between the anterior and middle lateral lobes of the glabella; visual surfaces very small, about twice as long as high, a little arcuate and directed nearly laterally; palpebral lobes small, rather prominent, and capping as it were the visual surfaces. Movable cheeks, with thick, rounded lateral margins, defined by a distinct rounded marginal furrow, continuous with that separating the anterior end of the glabella from the prominent arched middle of the anterior margin. Fixed cheeks provided with a very deep, broad furrow along their posterior margins. Facial sutures directed forward anteriorly, so as to intersect the margins somewhat nearer together than the breadth across between the eyes; posteriorly, sometimes slightly furrowed and directed at first a little obliqnely backward and outward from the eyes for less than half their length, then curving somewhat abruptly, and extending more obliquely backward nearly straight to, or very slightly in front of the posterior angles of the cheeks; rostral shield strongly arched, about twice and a half as long, measuring directly across from its lateral extremities, as the height from its upper to the lower margin at the middle. Labrum or hypostome longitudinally oblong with sinuous lateral margins; anterior end a little wider than any other part, with a convex outline, anterior margin prominent, rather deeply notched in the middle,

with a projecting point on each side of the notch. Internal surface concave; external convex and smooth.

Thorax about twice the length of the middle of the cephalic shield, narrowing backward, and very strongly trilobate; mesial lobe as wide as the lateral, and distinctly more convex, rounded or somewhat depressed on top and having its thirteen segments usually a little thickened at their ends, but without nodes. Lateral lobes separated from the middle one by distinct furrows somewhat flattened on the inner third, and rounding off more or less strongly to the lateral margins; pluræ extending straight outward for about one-fourth to one-third of their length, and then slightly deflected and curved backward to their outer ends, which are rounded, compressed, somewhat expanded, and provided with a thickened marginal ridge (not seen externally), while the anterior face of their outer valves are strongly flattened or beveled for sliding upon each other in rolling up; each with its longitudinal furrow well defined, and placed so as to divide off, as it were, its anterior third, though this is not seen more than half way out from their inner ends, when the thorax is folded together.

Pygidium one-half to two-thirds the length of the middle of the cephalic shield, wider than long, with a more or less nearly sub-trigonal outline, the anterior margin, however, generally being so rounded as to impart a nearly transversely sub-oval form to the general outline; mesial lobe well defined, depressed, convex, and extending very nearly to the posterior margin, showing five or six segments, the last two being very faintly defined, while behind these there is space enough for two or three more. Lateral lobes sloping or curving off more or less rapidly, each with about five segments, only the anterior one of which has a furrow like that of each of the pleuræ. Entire surface finely and evenly granular. (Meek.)

Horizon and localities—Lower Silurian, Trenton limestone: St. Louis county, Cape Girardeau.

Calymene rugosa SHUMARD.

Calymene rugosa Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 200, pl. B, fig. 14.

Pygidium about two-thirds as long as wide; posterior margins nearly straight, sharply rounded in the vicinity of the median lobe. Axial lobe not quite one-third the lobal width of the pygidium, composed of eight segments separated by sharp, rather deep grooves. The lateral lobes have about five segments, each one having a shallow median furrow which divides it into two nearly equal parts.

Horizon and localities.—Upper Cambrian? limestone: Birmingham (Cape Girardeau).

Ptychoparia conica? (BILLINGS).

Bathyurus conicus Billings, 1859: Can. Geol., vol. IV, p. 336.

Horizon and localities.—Cambrian, Magnesian limestone: Hazelton (Texas county).

Proetus missouriensis SHUMARD.

Proetus missouriensis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 196, pl. B, figs. 13a-b.

Proetus auriculatus Hall, 1861: Desc. New Species Foss., p. 79.

Proetus auriculatus Hall, 1862: New York State Cab. Nat. Hist., 15th Rep., p. 107.

Phillipsia shumardi Herrick, 1887: Bul. Dennison Univ, vol. II, p. 58, pl. vii, fig. 14.

Proetus missouriensis Vogdes, 1887: Ann. New York Acad. Sci., vol. IV, p. 75, pl. iii, fig. 1.

Proetus missouriensis Hall, 1888: Pal. New York, vol. VII, p. 133, pl. xxiii, fig. 32.

Much larger than *P. swallovi.* Glabella large, ovoid, broadly rounded, and a little flattened in front, slightly broader behind than before; the posterior pair of furrows is more strongly marked than the two other pairs. Pygidium semi-circular, somewhat flattened, with a broad marginal area. Axial lobe occupying about one-third the breadth of the entire tail-piece; segments, 10 in number, with strongly defined furrows separating them. Entire surface covered with small granules, which are larger on the glabella than elsewhere.

Horizon and localities.—Lower Carboniferous, Louisiana (Lithographic) limestone: Hannibal, Louisiana, Chouteau Springs (Cooper county).

Proetus swallovi SHUMARD.

Proetus swallovi Shumard, 1855: Geol. Sur. Missouri, Ann. Rept., p. 196, pl. B, figs. 12a–b.

Proetus (*Phillipsia*) *swallovi* Herrick, 1887: Bul. Dennison Univ., vol. II, p. 58.

Cephalic shield semicircular, arched; exterior border rather narrow, slightly elevated and marked by four or five filiform lines; marginal sinus narrow, shallow and rather poorly defined; posterior border of the cheeks rather wide and limited internally by a shallow yet distinct furrow. Glabella tumid, considerably elevated above the plane of the cheeks, and occupying about four-fifths the entire length of the head; it is rather more than half as wide as long, regularly rounded in front, with sides in front of the eyes convex; divided into four parts or lobes by three rather shallow grooves on each side; occipital segment convex, slightly wider than the base of the glabella, and about as high; occipital furrow slightly curved toward the front, narrow, rather deeply impressed, widest at the ends. Facial suture slightly impressed. Cheeks elevated in the middle, sloping rapidly downward toward the borders. Eyes reniform, moderately well developed, not quite as high as the glabella; visual surface minutely reticulated. Thoracic segments nine in number; axial lobe much elevated, wider than the lateral lobes, annulations wide, flattened in the direction of the axis, and separated from one another by narrow but well-defined grooves. Pygidium about as long as wide and equal in length to the head, broadly rounded behind, moderately convex, with a rather wide border; median lobe as wide as the lateral, moderately elevated, composed of seven flattened segments, which are separated by straight though very slightly impressed sutures. Surface minutely punctate. (Shumard.)

Horizon and localities.— Lower Carboniferous, Louisiana (Lithographic) limestone: Chouteau Springs (Cooper county).

Phillipsia sedaliensis (Vogdes).

Griffithides? sedaliensis Vogdes, 1888: Trans. N. Y. Acad. Sci., vol. VII, p. 249.
Phæthonides sedaliensis Herrick, 1889: Bul. Dennison Univ., vol. III, p. 57.

Closely related to *P. tuberculata*, but has twelve instead of seventeen segments in the pygidium, and also has about twice as many ornamental tubercles.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Phillipsia sampsoni Vogdes.

Phillipsia sampsoni Vogdes, 1888: Trans. N. Y. Acad. Sci., vol. VII, p. 248, 2 figs.

Closely resembling *P. meramecensis*, but with only about half as many segments in the pygidium.

Horizon and localities.—Lower Carboniferous, Chouteau limestone: Sedalia.

Phillipsia tuberculata Meek & Worthen.

Plate xxxii, fig. 6.

Phillipsia tuberculata Meek & Worthen, 1870: Proc. Acad. Nat. Sci., Phila., p. 52.

Horizon and localities.—Lower Carboniferous, Burlington limestone: Sedalia.

Phillipsia missouriensis Shumard.

Phillipsia missouriensis Shumard, 1858: Trans. St. Louis Acad. Sci., vol. 1, p. 225.
Phillipsia missouriensis Herrick, 1887: Bul. Dennison Univ., vol. II, p. 59.
Phillipsia missouriensis Vogdes, 1887: Ann. New York Acad. Sci., vol. IV, p. 86, pl. iii, figs. 1, 2, 14, 16.

Horizon and localities.—Upper Carboniferous, Coal Measures: Lexington.

Phillipsia meramecansis Shumard.

Phillipsia meramecansis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p. 199, pl. B, fig. 9.
Phillipsia meramecansis Herrick, 1887: Bul. Dennison Univ., vol. II, p. 59.
Phillipsia meramecansis Vogdes, 1887: Ann. New York Acad. Sci., vol. IV, p. 86, pl. iii, fig. 15.

Phillipsia meramecansis Herrick, 1889: Bul. Dennison Univ., vol. III, p. 28, pl. xi, fig. 3.
Phillipsia meramecansis Herrick, 1889: Bul. Dennison Univ., vol. IV, p. 54, pl. i, fig. 6.

Pygidium semi-elliptic, slightly wider than long, very convex; marginal flattening rather narrow. Median lobe somewhat narrower than, and elevated above, the lateral lobes; anterior end considerably curved, posterior obtusely pointed; segments thirteen in number, quite convex centrally, becoming flattened on the sides; the separating furrows rather deep. Lateral lobes strongly curved downward. Surface strongly granulose.

Horizon and localities.—Lower Carboniferous, Keokuk limestone: Saint Louis, Fenton (Saint Louis county).

Phillipsia portlockii MEEK & WORTHEN.

Plate xxxii, fig. 7.

Phillipsia portlockii Meek & Worthen, 1865: Proc. Acad. Nat. Sci., Phila., p 268.
Phillipsia (Griffithides) portlockii Meek & Worthen, 1873: Geol. Sur. Illinois, vol. V, p. 525, pl. xix, figs. 6a–c.

Entire outline sub-ovate. Cephalic shield sub-semicircular, nearly twice as wide as long, moderately convex, rounded in front and straight behind, with posterior lateral angle terminating in short-pointed, spine-like appendage extending back to thoracic segment. Glabella ovate, tumid, contracted and depressed behind, widest and most convex or ventricose anteriorly, where it is about one-third narrower than its length from the neck segment to its rounded front, which is not margined by a protecting rim; very distinct from the cheeks in consequence of its greater convexity; posterior lateral lobes small, much depressed, and insolated by the oblique lateral furrows in the front, being so directed as to intersect the neck furrow; immediately in front of these there are on each side faint traces of a small, very obscurely defined lateral lobe; anterior lobe ovate, ventricose, and comprising more than one-tenth of the whole; neck furrow deep and broad; its continuation across the posterior side of the cheek distinct, straight, and terminating at the lateral furrows of the cheeks; neck segment prominent, twice the size of the thoracic segments, and

equaling the greatest transverse diameter of the glabella in front, but more depressed. Eyes in the form of somewhat oval, ventricose tubercles, considerably lower than the glabella, from which they are separated by rather wide, distinct depressions, placed about one-half their length in advance of the posterior margin of the cheeks, and without visible facets; palpebral lobes depressed, not covering the eyes, but merely connecting with their inner sides, so as to leave the visual area forming an almost insolated tubercle. Cheeks sloping from the eyes into a broad deep marginal sulcus, which is not continued around the front of the glabella. Facial sutures cutting the anterior margin nearly on a line with the eyes, but curving so as to leave a small semi-circular wing on each anterior lateral margin of the glabella; behind they intersect the posterior margin of the cheeks about midway between the lateral angles and the neck segment, but nearer the latter.

Thorax nearly as long as the glabella, exclusive of the neck segment, distinctly trilobate; axial lobe slightly wider than the lateral lobes, rounded and rather prominent; its segments narrow and straight, or not arched forward. Lateral lobes more depressed, somewhat flattened on the inner side, rounding down to the lateral margins; segments duplicated by a nearly mesial furrow extending from their inner ends out to or a little beyond the undefined knee, beyond which they are obliquely flattened for folding together and rounded at their extremities. Pygidium a little more than one-fourth wider than long, rather distinctly convex, rounded behind and more or less straight in front, with anterior lateral angles obliquely truncated and a little rounded. Mesial lobe very prominent and well defined, rounded above, and a little flattened or furrowed on the sides; as wide anteriorly as the lateral lobes; tapering and declining somewhat posteriorly to an abrupt obtuse, prominent termination; about half its own greatest anterior breadth within the flattened margin; segments fourteen or fifteen, distinctly defined, smaller than those of the thorax. Lateral lobes depressed below the mesial lobe, somewhat flattened on the inner side, and sloping to the rather narrow

and more flattened border; segments ten, somewhat oblique, well defined for three-fourths of the distance out, and thence less distinctly so, to within a short distance of the margin; a few of the anterior ones with an obscure longitudinal furrow.

Surface granular, the granules being largest on the posterior portions of the glabella, palpebral lobes and neck segment. On the segments of the axial lobe, both of the thorax and pygidium, as well as those of the lateral lobes, they are very small, and regularly disposed so as to form a single row on each segment. (Meek.)

Horizon and localities.—Lower Carboniferous, Keokuk limestone: St. Francisville (Clark county); Keokuk (Iowa).

Phillipsia? immaturus (Herrick).

Phæthonides immaturus Herrick, 1889: Bul. Dennison Univ., vol. IV. p 59, pl. i, figs. 9 and 15.

Closely related to *P. tuberculata*, but very much smaller.

Horizon and localities.—Lower Carboniferous, Lower Burlington limestone: Louisiana.

Phillipsia major Shumard

Plate xxxii, figs. 8a-e.

Phillipsia major Shumard, 1858: Trans. St. Louis Acad. Sci., vol. I, p. 226.
Phillipsia major Meek, 1872: U. S. Geol. Sur. Nebraska, p. 238, pl. iii, figs. 2a-c.
Phillipsia major Herrick, 1887: Bul. Dennison Univ., vol. II, p. 60.
Phillipsia major Vogdes, 1887: Ann. N. Y. Acad. Sci., vol. IV, p. 85, pl. iii, fig. 14.

Pygidium semi-elliptic, slightly longer than wide, broadest anteriorly, very convex; margins nearly straight on the sides, rather sharply rounded behind. Median lobe considerably raised above the lateral ones, distinctly compressed and furrowed on each side, strongly arched longitudinally, and narrowing posteriorly; segments twenty-three in number, not curved forward or backward, the ones toward the front not well defined by sutural furrows. Lateral lobes broader than the central one, turned abruptly downward on outer side, and sloping more gradually behind into a smooth border which continues around the free margins; segments about thirteen, moderately oblique.

Surface smooth, or sometimes showing faint traces of minute granules or small, scattering pits.

Horizon and localities.—Upper Carboniferous, Upper Coal Measures: Kansas City.

Leperditia sublævis (Shumard).

Cythere sublævis Shumard, 1855: Geol. Sur. Missouri, Ann. Rep., p 195. pl. B, fig. 15.

Leperditia sublævis Vogdes, 1890: U. S. Geol. Sur., Bul. 63, p. 172.

"Carapace small, subovate, smooth, nearly as long again as high, moderately convex, most prominent posteriorly; posterior end a little wider than the anterior, rounded; ventral margin straight, its anterior extremity extended into a minute pointed process. Just within the borders a faintly impressed line may be traced entirely around the valves. Surface highly polished." (Shumard.)

Horizon and localities.—Silurian, First Magnesian limestone: Hamilton creek (St. Louis county), Ste. Genevieve county, Spencer creek (Ralls county).

Solenocaris sancti-ludovici Worthen.

Solenocaris sancti-ludovici Worthen, 1884: Illinois State. Mus. Nat. Hist., Bul. 2, p. 4.

Solenocaris sancti-ludovici Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 153, pl. xxviii, fig. 3.

Carapace narrow, much elongated, being three times as long as high, slightly convex; dorsal and ventral margins nearly straight.

Horizon and localities.—Lower Carboniferous, Saint Louis limestone: Saint Louis.

Colpocaris chesterensis Worthen.

Colpocaris chesterensis Worthen, 1884: Illinois State Mus. Nat. Hist., Bul. 2, p. 3.

Colpocaris chesterensis Worthen, 1891: Geol. Sur. Illinois, vol. VIII, p. 153, pl. xxviii, fig. 2.

Carapace large, subovate, twice as long as high, with regularly curving margins.

Horizon and localities.—Lower Carboniferous, Kaskaskia limestone: Chester (Illinois).

Stratigraphic Catalogue of Missouri Fossils.

BY CHARLES R. KEYES.

The catalogue of fossils belonging to the various geological formations of Missouri is based upon the report on the Paleontology of the state which forms volumes IV and V of the subject reports. The arrangement is a zoological one, following that in the report.

In bringing together the ancient forms of life which flourished during each geological epoch, there is at once brought to notice a striking disparity in the distribution of the forms. In some formations only a few organic remains are recorded; in others there is the greatest profusion. The unequal distribution is perhaps more apparent than real. A number of causes lead to these results: First, and most important perhaps, is the unequal search for fossils. Second is the unequal detection of the fossils. Third is the original irregularity in distribution. Fourth is the numerical disproportion. Fifth is the difference in preservation. Sixth is the inherent variation of parts capable of retaining their original indentity.

The disparity of search is one of those things which is governed largely by chance. No effort of organized work can overcome it. Local collectors spring up in certain places, and for a long period of years carry on the work of accumulating the fossils of the county or immediate locality with untiring zeal and energy. The result of their labors cannot be duplicated in a generation, nor can their success be attained even after years of constant and systematic application. As a matter of fact, then, an investigation of the paleontology of a district is dependent largely upon the collections made by a comparatively few persons scattered over the area, who have

been interested in the work from the love of it, with no hope or desire for pecuniary reward. Thus it happens that the investigation at the outset is necessarily unequally developed. While a state geological survey is able to collect a large amount of valuable material, fill in wide gaps and acquire much information on the subject, its direct efforts are for the most part incidental—those observations which are made being in the course of other investigations of an economic character. To this, as much as to any other reason, perhaps, is due the great wealth of species in the Lower Carboniferous and Coal Measures, and the comparatively great paucity in some of the other formations. As a further aid to unequal search for fossils is the unavoidable difference of attention which the various formations receive, especially in the early progress of the survey, owing to the fact that all subjects cannot be commenced at once. Consequently in carrying on the work on particular subjects, as for example lead and zinc, or coal, certain geological formations have more attention devoted to them in a single year, or even during a few months, than others do in several years. The fossils obtained from one horizon, even though they were originally equally distributed, would surpass many times those obtained during the same period from all the other formations combined.

In the unequal detection of fossils lies the second great cause of disparity. Rocks present very different adaptations to preservation. Sandstones usually are devoid of animal remains, for the reason that percolating waters remove the hard parts originally entombed. Many shales are practically unfossiliferous. Some limestones contain no traces of life whatever, while others are almost wholly composed of organic remains. Coal, gypsum and certain other beds are also without good fossils. On the other hand, beds which were originally very prolific with fossils often lose all or nearly all traces through subsequent change in the composition of the rock. Thus, highly fossiliferous limestones, in altering to dolomites, have the organic remains largely obliterated in the process.

It is quite manifest that there is a very marked irregularity in the distribution of all fossil forms. While it is largely original and real, it is in part only illusory. As in the modern sea bottom, there are broad stretches where life is comparatively infrequent; others where organisms are collected together in great confused masses. Again, life is more abundant in some zones than in others; and at certain depths. Exposed places are liable to be less frequented by animals than quiet, secluded ones.

The disproportion of numbers is readily comprehended in a comparison between an almost unfossiliferous limestone and one of the encrinital beds of the Lower Carboniferous, which is made up almost entirely of the disjointed hard parts of organisms, among which, however, are abundant remains of only partially destroyed structures. When beds of this kind 20 or 30 feet thick and miles in extent are known, as in the case of the Burlington limestones, it is perfectly inconceivable what myriads of organisms must have flourished and died to supply the material for such vast deposits. Very different is it with strata many times thicker and far more extensive, yet containing not the slightest trace of ancient life.

Granting the original prevalence of organisms in a given area, diverse vicissitudes overtake the remains after they are first entombed. Taking into account only those forms of life which have hard parts sufficient to not immediately disappear at death, relatively few traces ultimately remain. Percolating waters remove the lime salts. Changes in the lithological character of the rocks deform, disguise or obscure the remains. When metamorphic action is intense all traces of organisms are often completely obliterated. Thus, two associated beds equally fossiliferous in the beginning may become finally very different in this respect in the end.

The sixth cause for disparity in the distribution of fossils lies in the inherent capability of retaining their durability through all the changes and accidents of time. Chemical composition and character of the structures may be here mentioned.

With the many natural difficulties to be taken into consideration, it is readily understood that from a geological or biological point of view, any stratigraphic tabulation of the fossils of the state must necessarily be quite incomplete for years to come, and must long lack uniformity in the number and kind of organisms assigned to each horizon. Nevertheless, in the present condition there is a peculiar economic importance in a special arrangement of the forms known at the present time to occur within the limits of Missouri or on its borders, according to the strata in which they are found. With the general geographical distribution known by reference to the colored geological map, the fossils which may be expected to be found in any locality in the state may be quickly referred to without the labor of going through the whole report to pick them out. The fossils forming as they do labels to the deposits of commercial value, put a ready and inexpensive means in the hands of even the most inexperienced for determining what minerals of economic worth are to be sought for in the particular neighborhood, and what are not to be expected.

CAMBRIAN.

Ozark Series.

Linguella lamborni, Meek.
Ophileta compacta, Salter.
Murchisonia melaniaformis, Shumard.
Raphistoma subplana, Shumard.
Straparollus valvatiformis, Shumard.
Orthoceras ozarkensis, Shumard.
Lituites complanata, Shumard.

SILURIAN.

Calciferous.

Camerella calcifera ? Billings.
Leperditia sublævis (Shumard).
Ptychoparia conica (Billings).

Trenton.

Receptaculites oweni, Hall.
Columnaria stellata (Hall).
Streptelasma corniculum, Hall.
Comarocystites, obconicus, Meek & Worthen.
    shumardi, Meek & Worthen.
Ptychocrinus splendens (Miller).
Calymene senaria, Conrad.
Homotrypa arbuscula, Ulrich.
Phacelopora pertenuis, Ulrich.
Orthis fissicosta, Hall.
    occidentalis, Hall.
Platystrophia lynx (Eichwald).
Strophomena deltoidea, Conrad.
Zygospira modesta (Say).
Bellerophon bilobatus, Sowerby.
Cyclonema bilex (Conrad).
Murchisonia gracilis, Hall.
    major, Hall.
    carinifera, Shumard.
Maclurea magna, Le Sueur.
Raphistoma lenticularis (Conrad).
Subulites elongatus, Conrad.
Trochonema umbilicata (Hall).
Endoceras elongatum ? Hall.
Gonioceras anceps, Hall.
Orthoceras arcuoliratum ? Hall.

Hudson.

Glyptocrinus fornshelli, Miller.
Acidaspis halli, Shumard.
Cyphaspis girardeauensis, Shumard.
Encrinurus deltoideus, Shumard.
Leptæna mesacosta, Shumard.
  sericea, Sowerby.
Orthis emacerata, Hall.
  missouriensis, Shumard.
  subquadrata, Hall.
  tricenaria, Conrad.
Platystrophia acutilirata (Conrad).
Plectambonites rhomboidalis (Wilckens).
Rhynchonella capax (Conrad).
  dentata (Hall).
Streptorhynchus filitexta (Hall).
Strophomena alternata (Conrad).
  planumbona (Hall).
Tentaculites incurvus, Shumard.

"Niagara."

Striatopora missouriensis, Meek & Worthen.
Favosites favosa (Goldfuss).
  hemispherica (Troost).
Edriocrinus pocilliformis, Hall.
Acidaspis hamata (Conrad).
Calymene rugosa, Shumard.
Dalmanites tridentifera (Shumard).
Illænus graftonensis, Meek & Worthen.
  insignis, Hall.
Lichas boltoni (Bigsby).
Eatonia pecularis ? (Conrad).
Meristella lævis (Vanuxem).
Nucleospira pisiformis, Hall.
Orthis subcarinata, Hall.
Spirifera perlamellosa (Hall).
Streptorhynchus subplana (Conrad).
Trematospira imbricata ? (Hall).
Zygospira subconcava, Meek & Worthen.
Capulus subsinuosus (Worthen).
Igoceras pyramidatum (Hall).
Orthonychia spirale (Hall).
Orthoceras medullare, Hall.
  jolietense, Meek & Worthen.

DEVONIAN.

Stromatopora expansa, Hall & Whitfield.
Acervularia davidsoni, Edwards & Haime.
Cyathophyllum cornicula, Rominger.
Cystophyllum americanum, Edwards & Haime.
Athyris vittata, Hall.
Atrypa occidentalis, Hall.
    reticularis (Linnæus).
Cyrtina dalmani (Hall).
    umbonata (Hall).
Orthis iowensis, Hall.
Pentamerus salinensis, Swallow.
Productella subalata (Hall).
Spirifera ligus, Owen.
    parryana, Hall.
Strophodonta? cymbiformis, Swallow.
    demissa (Conrad).
Syringothyris occidentalis (Swallow).

CARBONIFEROUS.

Kinderhook.

Amplexus blairi, Miller.
    yandelli, Edwards & Haime.
Chonophyllum sedaliense, White.
Cleistopora placenta (White)
Conopterium effusum, Winchell.
Cyathophyllum glabrum, Keyes.
Microcyclus blairi, Miller.
Palæacis enormis (Meek & Worthen).
Phillipsia sampsoni, Vogdes.
Phillipsia sedaliensis (Vogdes).
Syringopora sp?
Zaphrentis acuta, White & Whitfield.
    calceola, White & Whitfield.
    chouteauensis, Miller.
    exigua, Miller.
    tantilla, Miller.
    tenella, Miller.
Actinocrinus arrosus (Miller).
Agaricocrinus brevis (Hall).
    planoconvexus, Hall.
Dorycrinus chouteauensis (Miller).
Gennæocrinus trijugis (Miller).
Platycrinus absentivus, Miller.
    æquiternus, Meek.
    allophylus, Miller.
    annosus, Miller.
    ollicula, Miller.

Proetus missouriensis, Shumard.
swallowi, Shumard.
Platycrinus brittsi, Miller.
Scaphiocrinus? sampsoni, Miller.
Schizoblastus? roemeri (Shumard).
Ambocœlia minuta, White.
Athyris hannibalensis (Swallow).
proutii (Swallow).
Chonetes geniculata, White.
ornata, Shumard.
Crania lævis, Keyes.
Cyrtina acutirostris (Shumard).
Discina newberryi, Hall.
Orthis burlingtonensis, Hall.
Plectambonites rhomboidalis (Wilckens).
Productella pyxidata (Hall).
Productus arcuatus, Hall.
lævicostus, White.
Retzia ? osagensis, Swallow.
Rhynchonella cooperensis, Shumard.
missouriensis, Shumard.
Spirifera cooperensis, Swallow.
grimesi, Hall.
marionensis, Shumard.
peculiaris, Shumard.
subrotundata, Hall.
taneyensis, Swallow.
Spiriferina clarksvillensis, Winchell.
Streptorynchus lens, White.
Syringothyris carteri (Hall).
extenuata (Hall).
Allorisma hannibalensis, Shumard.
Cardiomorpha triangulata, Swallow.
Entolium circulus (Shumard).
cooperensis (Shumard).
Conularia marionensis, Swallow.
Aclisina bellilineata, Miller.
Bellerophon panneus, White.
Capulus haliotoides (Meek & Worthen).
paralius (White & Whitfield).
Loxonema tenuilineata (Shumard).
Pleurotomaria lens (Hall).
sedaliensis, Miller.
Goniatites gorbyi, Miller.
osagensis, Swallow.
Nautius ? burlingtonensis (Owen).
digonus, Meek & Worthen.
Orthoceras chouteauense, Swallow.
Phragmoceras ? missouriensis, Miller.

Augusta.

CORALS—

Amplexus blairi, Miller.
fragilis, White & St. John.
Aulopora gracilis, Keyes.
Palæacis obtusa (Meek & Worthen).
Echinodiscus sampsoni, Miller.
Hadrophyllum glans, White.
Striatopora carbonaria, White.
Syringopora harveyi, White.
Zaphrentis centralis, Worthen.
dalei, Edwards & Haime.
elliptica, White.
illinoisensis, Worthen.
spergenensis, Worthen.
spinulosa, Edwards & Haime.
tantilla, Miller.
varsavensis, Worthen.

ECHINODERMS—

Archæocidaris agassizi, Hall.
keokuk, Hall.
shumardiana, Hall.
Oligoporus danæ (Meek & Worthen).
mutatus, Keyes.
Onychaster asper, Miller.
Cryptoblastus melo (Owen & Shumard).
Granatocrinus neglectus (Meek & Worthen).
norwoodi (Owen & Shumard).
Metablastus bipyramidalis (Hall).
lineatus (Shumard).
wortheni (Hall).
Orophocrinus companulatus (Hambach).
stelliformis (Owen & Shumard).
Pentremites conoideus, Hall.
elongatus, Shumard.
Schizoblastus melonoides (Meek & Worthen).
sayi (Shumard).
Actinocrinus brittsi, Miller.
cœlatus, Hall.
fossatus, Miller.
glans, Hall.
jugosus, Hall.
lobatus, Hall.
lowei, Hall.
multiradiatus, Shumard.

obesus, Keyes.
pernodosus, Hall.
proboscidialis, Hall.
reticulatus, Hall.
scitulus, Meek & Worthen.
tenuisculptus, McChesney.
thalia, Hall.
verrucosus, Hall.
Agaricocrinus americanus (Roemer).
brevis (Hall).
pentagonus, Hall.
planoconvexus, Hall.
wortheni, Hall.
Amphoracrinus divergens (Hall).
Calceocrinus tunicatus (Hall).
ventricosus (Hall).
Cyathocrinus boonvillensis, Miller.
enormis (Meek & Worthen).
iowensis, Owen & Shumard.
Dorycrinus cornigerus (Hall).
elegans, Miller.
gouldi (Hall).
kelloggi, Worthen.
missouriensis (Shumard).
mississippiensis, Roemer.
parvus (Shumard).
subaculeatus (Hall).
unicornis (Owen & Shumard),
Dichocrinus blairi, Miller.
ficus, Cassady & Lyon.
lineatus, Meek & Worthen.
liratus, Hall.
striatus, Owen & Shumard.
Batocrinus æqualis (Hall).
æquibrachiatus (McChesney).
biturbinatus (Hall).
blairi, Miller.
calvini, Rowley.
christyi (Shumard).
clypeatus (Hall).
dodecadactylus (Meek & Worthen).
elegans (Hall).
euconus (Meek & Worthen).
laura (Hall).
longirostris (Hall).
nashvillæ (Troost).
planodiscus (Hall).
pulchellus, Miller.
pyriformis (Shumard).

rotundus (Yandell & Shumard).
trohiscus, Meek & Worthen.
subtractus (White).
Belemnocrinus? sampsoni, Miller.
Barycrinus hoveyi (Hall).
magnificus, Meek & Worthen.
meekianus (Shumard).
rhombiferus (Owen & Shumard).
spurius (Hall).
stellatus (Troost).
Eretmocrinus calyculoides (Hall).
carica (Hall).
corbulis, Hall.
coronatus (Hall).
depressus, Keyes.
expansus, Keyes.
konincki (Shumard).
leucosia (Hall).
originarius, Wachsmuth & Springer.
remibrachiatus (Hall).
verneuillianus (Shumard).
Eucladocrinus pleuroviminus (White).
orbicularis (Hall).
Forbeslocrinus agassizi, Hall.
wortheni, Hall.
Gibertsocrinus typus (Hall).
Ichthyocrinus burlingtonensis, Hall.
Megistocrinus brevicornis (Hall).
evansi (Owen & Shumard).
Rhodocrinus coxanus, Worthen.
wachsmuthi, Hall.
whitei, Hall.
wortheni, Hall.
Parisocrinus intermedius (Hall).
Periechocrinus? whitei (Hall).
Physetocrinus ornatus (Hall).
ventricosus (Hall).
Platycrinus æqualis, Hall.
americanus, Owen & Shumard.
burlingtonensis, Owen & Shumard.
bonoensis, White.
boonvillensis, Miller.
discoideus, Owen & Shumard.
halli, Shumard.
pileiformis, Hall.
præauntius, Wachsmuth & Springer.
pratteni, Worthen.
saffordi, Troost.
sampsoni, Miller.

sculptus, Hall.
subspinosus, Hall.
Poteriocrinus brittsi, Miller.
Scaphiocrinus ? gorbyi, Miller.
boonvillensis, Miller.
rusticellus (White).
Steganocrinus araneolus (Meek & Worthen).
concinnus (Shumard).
pentagonus (Hall).
sculptus (Hall).
Strotocrinus regalis (Hall).
Symbathocrinus dentatus, Owen & Shumard.
swallowi, Hall.
wortheni, Hall.
Taxocrinus giddingei (Hall).
thiemi (Hall).
Teliocrinus liratus (Hall).
umbrosus (Hall).
Woodocrinus elegans (Hall).
pocillum (Miller).

CRUSTACEANS—

Phillipsia immaturus (Herrick).
meramecansis, Shumard.
portlockii, Meek & Worthen.
tuberculata, Meek & Worthen.

POLYZOANS—

Actinotrypa pecularis (Rominger).
Archimedes owenanus, Hall.
wortheni, Hall.
Coscinium ? latum, Ulrich.
Cyclopora expatiata, Ulrich.
fungia, Prout.
Cycloporella perversa, Ulrich.
spinifera, Ulrich.
Cystodictya americana, Ulrich.
nitida, Ulrich.
pustulosa, Ulrich.
Bactropora simplex, Ulrich.
Evactinopora grandis, Meek & Worthen.
radiata, Meek & Worthen.
sexradiata, Meek & Worthen.
Fenestella cingulata, Ulrich.
filistriata, Ulrich.
funicula, Ulrich.
limitaris, Ulrich.
multispinosa, Ulrich.
rudis, Ulrich.
serratula, Ulrich.

Fistulipora compressa, Rominger.
Glyptopora elegans (Prout).
megastoma, Ulrich.
keyserlingi (Prout).
sagenella (Prout).
Hemitrypa aspera, Ulrich.
nodosa, Ulrich.
pateriformis, Ulrich.
perstriata, Ulrich.
Leioclema foliatum, Ulrich.
gracillimum, Ulrich.
punctatum (Hall).
Lyropora retrosa, Meek & Worthen.
Rhombopora attennata, Ulrich.
dichotoma, Ulrich.
transversalis, Ulrich.
varians, Ulrich.
Pinnatopora conferta, Ulrich.
vinei, Ulrich.
youngi, Ulrich.
Polypora gracilis, Prout.
halliana, Prout.
maccoyana, Ulrich.
radialis, Ulrich.
retrosa, Ulrich.
simulatrix, Ulrich.
spininodata, Ulrich.
Prismopora trifolia (Rominger).
Proutella discoidea, Prout.
Ptilopora acuta, Ulrich.
cylindracea, Ulrich.
valida, Ulrich.
Stenopora americana, Ulrich.
angularis, Ulrich.
emanciata, Ulrich.
intercalaris, Ulrich.
intermittens, Ulrich.
montifera, Ulrich.
Stictoporella basalis, Ulrich.
Streblotrypa major, Ulrich.
radialis, Ulrich.
Strotopora dermata, Ulrich.
foveolata, Ulrich.
Tæniodictya frondosa, Ulrich.
ramulosa, Ulrich.
Worthenopora spinosa, Ulrich.

BRACHIOPODS—

Athyris formosa (Swallow).
    incrassatus, Hall.
Chonetes logani, Norwood & Pratten.
    illinoisensis, Worthen.
Orthis burlingtonensis, Hall.
    swallowi, Hall.
    keokuk, Hall.
Rhynchonella boonensis, Shumard.
    mutata, Hall.
    ringens, Swallow.
    subcuneata, Hall.
    subtrigona, Meek & Worthen.
Plectambonites rhomboidalis (Wilckens).
Productus biseriatus, Hall.
    burlingtonensis, Hall.
    lævicostus, White.
    magnus, Meek & Worthen.
    vittatus, Hall.
Spirifera forbesi, Norwood & Pratten.
    grimesi, Hall.
    imbrex, Hall.
    kelloggi, Swallow.
    keokuk, Hall.
    lineatoides, Swallow.
    logani, Hall.
    pseudolineata, Hall.
    rostellata, Hall.
Syringothyris carteri (Hall).
    plena (Hall).
    texta (Hall).
Terebratula parva, Swallow.
    rowleyi, Worthen.

LAMELLIBRANCHS—

Aviculopecten magna (Swallow).
Chonocardium, sp.?
Edmondia burlingtonensis, White & Whitfield.
    nuptialis, Winchell.
Lithophaga, sp.?
Myalina keokuk, Worthen.

GASTEROPODS—

Bellerophon bilabiatus, White & Whitfield.
Capulus biserialis (Hall).
    equilateralis (Hall).

latus (Keyes).
obliquus (Keyes).
tribulosus (White).
Dentalium primarium, Hall.
Igoceras capulus (Hall).
fissurella (Hall).
pabulocrinus (Owen).
quincyense (McChesney).
Omphalotrochus springvalensis (White).
Orthonychia acutirostre (Hall).
boonvi lense (Miller).
crytolites (McChesney).
formosum (Keyes).
Phanerotinus paradoxus, Winchell.
Pleurotomaria montezuma, Worthen.
subcarbonaria, Keyes.
Porcellia nodosa, Hall.
Soleniscus cooperensis (Swallow).
Sphærodoma penguis (Winchell).
Straparollus ammon (White & Whitfield).
latus (Hall).
obtusus (Hall).
Strophostylus reversus (Hall).
Conularia missouriensis, Swallow.
osagensis, Swallow.

CEPHALOPODS—

Goniatites osagensis, Swallow.

VERTEBRATES—

Chomatodus parallelus, St. John & Worthen.
Ctenacanthus excavatus, St. John & Worthen.
keokuk, St. John & Worthen.
Deltodus littoni, Newberry & Worthen.
Deltoptychius wachsmuthi, St. John & Worthen.
Desmiodus? flabellum, St. John & Worthen.
ligoniformis, St. John & Worthen.
Batacanthus baculiformis, St. John & Worthen.
Gampsacanthus? latus, St. John & Worthen.
Lambdodus calceolus, St. John & Worthen.
costatus, St. John & Worthen.
Lisgodus curtus, St. John & Worthen.
Plysonemus parvulus, St. John & Worthen.
Polyrhizodus williamsi, St. John & Worthen.
Venustodus tenuicristatus, St. John & Worthen.

Saint Louis.

CORALS—

Lithostrotion mamillare, Castelnau.
Zaphrentis spinulosa, Edwards & Haime.

ECHINODERMS—

Archæocidaris newberryi, Hambach.
wortheni, Hall.
Cryptoblastus kirkwoodensis (Shumard).
Granatocrinus curtus (Shumard).
Melonites crassus, Hambach.
Oligoporus parvus, Hambach.
Onychocrinus monroensis (Meek & Worthen).
Pentremites koninckanus, Hall.
Platycrinus saræ, Hall.
Scaphiocrinus dactyliformis, Hall.
missouriensis (Shumard).
proboscidialis (Worthen).
Scytalocrinus dactylus (Hall).
vanhornei (Worthen).
Talarocrinus simplex (Shumard).
Taxocrinus shumardianus (Hall).

CRUSTACEANS—

Solenocaris sancti-ludovici, Worthen.

POLYZOANS—

Amacanthus gibbosus (Newberry & Worthen).
Dichotrypa intermedia, Ulrich.
Fenestella banyana, Prout.
sancti-ludovici, Prout.
Glyptopora michelinia (Prout).
plumosa (Prout).
Hemitrypa hemitrypa, Prout.
Polypora biseriata, Ulrich.
varsaviensis, Ulrich.
Ptilopora prouti, Hall.
Stenopora tuberculata (Prout).
Worthenopora spatulata, Prout.

BRACHIOPODS—

Athyris trinuclea (Hall).
Orthis dubia, Hall.
Productus altonensis, Norwood & Pratten.
marginicinctus, Prout.
ovatus, Hall.
tenuicostus, Hall.

Retzia verneuiliana, Hall.
Rhynchonella ottumwa, White.
Spirifera leidyi, Norwood & Pratten.

LAMELLIBRANCHS—

Allorisma marionensis, White.
Aviculopecten missouriensis (Shumard).
Lithophaga pertenuis, Meek & Worthen.
Myalina sancti-ludovici, Worthen.
Pinna missouriensis, Swallow.

GASTEROPODS—

Bulimorpha bulimiformis (Hall).
Bellerophon sublævis, Hall.
Orthonychia acutirostra (Hall).
Straparollus spergenensis, Hall.
Strophostylus? carleyana (Hall).
Conularia missouriensis ?, Swallow.
subulata, Hall.

VERTEBRATES—

Asteroptychius sancti-ludovici, St. John & Worthen.
Chomatodus incrassatus, St. John & Worthen.
Cladodus eccentricus, St. John & Worthen.
elegans, Newberry & Worthen.
euglyphens, St. John & Worthen.
ischypus, Newberry & Worthen.
Cochliodus obliquus, St. John & Worthen.
vanhornei, St. John & Worthen.
Copodus vanhornei, St. John & Worthen.
Ctenacanthus gracillimus, Newberry & Worthen.
pugiunculus, St. John & Worthen.
Deltodopsis sancti-ludovici, St. John & Worthen.
Deltodus cinctulus, St. John & Worthen.
parvus, St. John & Worthen.
Deltoptychius expansus, St. John & Worthen.
Desmiodus costelliformus, St. John & Worthen.
tumidus, St. John & Worthen.
Drepanacanthus reversus, St. John & Worthen.
Erismacanthus maccoyanus, St. John & Worthen.
Gampsacanthus squamosus, St. John & Worthen.
typus, St. John & Worthen.
Geisacanthus stellatus, St. John & Worthen.
Lecracanthus unguiculus, St. John & Worthen.
Harpacodus occidentalis, St. John & Worthen.
Lisgodus selluliformis, St. John & Worthen.
Marracanthus rectus (Newberry & Worthen).
Oracanthus consimilis, St. John & Worthen.
vetustus, Leidy.

Petalorhynchus distortus, St. John & Worthen.
Peltodus quadratus, St. John & Worthen.
Petalorhynchus pseudosagittatus, St. John & Worthen.
Physonemus falcatus, St. John & Worthen.
Polyrhizodus amplus, St. John & Worthen.
    littoni, Newberry & Worthen.
Pœcilodus sancti-ludovici, St. John & Worthen.
Psephodus latus, St. John & Worthen.
Psammodus planus, St. John & Worthen.
Sandalodus crassus, Newberry & Worthen.
    spatulatus, Newberry & Worthen.
Stenopterodus parvulus, St. John & Worthen.
Tanodus prænuntius, St. John & Worthen.
    sculptus, St. John & Worthen.
Vaticinodus ? simplex, St. John & Worthen.
Xystrodus imitatus, St. John & Worthen.

Kaskaskia.

CORALS—

Cleistopora typa (Winchell).
Zaphrentis chesterensis, Worthen.
    spinulosa, Edwards & Haime.
    cylindracea, Worthen.

ECHINODERMS—

Agassizocrinus dactyliformis, Troost.
Archæocidaris norwoodi, Hall.
Cromyocrinus globosus (Worthen).
Echinodiscus kaskaskiensis (Hall).
Eupachycrinus maniformis (Yandell & Shumard).
Pentremites godoni, Defrance.
    obesus, Lyon.
    pyriformis, Say.
    sulcatus, Roemer.
Pterotocrinus chesterensis (Meek & Worthen).
Scaphiocrinus scoparius, Hall.
Zeacrinus magnoliæformis (Owen & Shumard).

CRUSTACEANS—

Colpocaris chesterensis, Worthen.

POLYZOANS—

Anisotypa solida, Ulrich.
Archimedes laxus, Hall.
    swallovanus, Hall.
Batostomella nitidula, Ulrich.
Diplopora bifurcata, Ulrich.
Fenestella cestriensis, Ulrich.
    elevatipora, Ulrich.

flexuosa, Ulrich.
tenax, Ulrich.
Leioclema areneum, Ulrich.
Lyropora divergens, Ulrich.
quincuncialis, Hall.
subquadrans, Hall.
Meekopora approximata, Ulrich.
clausa (Ulrich).
Myalina angulata, Meek & Worthen.
Polypora cestriensis, Ulrich.
corticosa, Ulrich.
spinulifera, Ulrich.
tuberculata, Prout.
Rhombopora tabulata, Ulrich.
tenuirama, Ulrich.
Septopora cestriensis, Prout.
Sphrogropora parasitica, Ulrich.
Stenopora cestriensis, Ulrich.
meekana, Ulrich.
tuberculata (Prout).
Streblotrypa distincta, Ulrich.
nicklesi, Ulrich.
Thamniscus furcillatus, Ulrich.

BRACHIOPODS—

Athyris sublamellosa, Hall.
subquadrata, Hall.
Productus cestriensis, Worthen.
Retzia vera, Hall.
Spirifera contracta, Meek & Worthen.
increbescens, Hall.
leidyi, Norwood & Pratten.
setigera, Hall.
Spiriferina spinosa (Norwood & Pratten).

LAMELLIBRANCHS—

Allorisma antiqua, Swallow.

GASTEROPODS—

Capulus ovalis (Stevens).
Dentalium missouriense, Swallow.
Orthoceras chesterense, Swallow.
Orthonychia chesterense (Meek & Worthen).
Sphærodoma littonana (Hall).
Straparollus planidorsatus (Meek & Worthen).

CEPHALOPODS—

Nautilus spectabilis, Meek & Worthen.

Coal measures.

PROTOZOANS—

Fusulina cylindrica, Fischer.

CORALS—

Axophyllum rude, White & St. John.
Campophyllum torquium (Owen).
Lophophyllum proliferum (McChesney).

ECHINODERMS—

Archæocidaris aculeata, Shumard.
    biangulata, Shumard.
    dininnii, White.
    hallianus (Geinitz).
    megastylus, Shumard.
Ceriocrinus hemisphericus (Shumard).
Cromyocrinus buttsi (Miller & Gurley).
    kansasensis (Miller & Gurley).
Eupachycrinus harii, Miller.
    magister, Miller & Gurley.
    verrucosus (White & St. John).
Hydreionocrinus acanthophorus (Meek & Worthen).
    mucrospinus (McChesney).
    pentagonus, Miller & Gurley.
Lecythiocrinus olliculæformis, White.
Phialocrinus barydactylus, Keyes.
    basiliscus (Miller & Gurley).
    carbonarius (Meek & Worthen).
    harii (Miller & Gurley).
    magnificus (Miller & Gurley).
    stillativus (White).

CRUSTACEANS—

Phillipsia major, Shumard.
    missouriensis, Shumard.

POLYZOANS—

Chætetes milleporaceus, Troost.
Fenestella shumardi, Prout.
Fistulipora carbonaria, Ulrich.
    nodulifera, Meek.
Rhombopora crassa, Ulrich.
    lepidodendroides, Meek.
Pinnatopora trilineata, Meek.
Polypora submarginata, Meek.
Septopora biserialis, Swallow.

BRACHIOPODS—

Athyris argentea (Shepard).
Chonetes flemingi, Norwood & Pratten.
granulifera, Owen.
lævis, Keyes.
mesoloba, Norwood & Pratten.
millepunctata, Meek & Worthen.
Discina convexa, Shumard.
nitida (Phillips).
Lingula umbonata, Cox.
Meekella striatocostata (Cox).
Orthis pecosii, Marcou.
Productus americanus, Swallow.
cora, d'Orbigny.
costatus, Sowerby.
longispinus, Sowerby.
nebrascensis, Owen.
punctatus (Martin).
semireticulatus (Martin).
symmetricus, McChesney.
Retzia mormoni (Marcou).
Rhynchonella uta (Marcou).
Streptorhynchus crassus (Meek & Hayden).
Spirifera camerata, Morton.
planoconvexus, Shumard.
perplexa, McChesney.
rockymountana, Marcou.
Spiriferina kentuckensis (Shumard).
Syntrilasma hemiplata (Hall).
Terebratula bovidens, Morton.

LAMELLIBRANCHS—

Allorisma costata, Meek & Worthen.
granosum (Shumard).
subcuneatum, Meek & Hayden.
topekaensis, Shumard.
Astartella concentrica (McChesney).
vera, Hall.
Avicula longa (Geinitz).
Aviculopinna americana, Meek.
Aviculopecten carboniferus (Stevens).
coryanus, White.
coxanus, Meek & Worthen.
fasciculatus, Keyes.
interlineatus, Meek & Worthen.
occidentalis (Shumard).
Cardiomorpha missouriensis, Shumard.

Chænomya leavenworthensis (Meek & Hayden).
minnehaha (Swallow).
Clinopistha radiata (Hall).
Concardium parrishi, Worthen.
Edmondia aspinwallensis, Meek.
glabra, Meek.
subtruncata, Meek.
Entolium aviculatum (Swallow).
Euhondria neglecta, (Geinitz).
Lima retifera, Shumard.
Macrodon obsoletus, Meek.
sangamonensis ?, Worthen.
tenuistriatus, Meek & Worthen.
Monopteria longispina (Cox).
gibbosa (Meek & Worthen).
Monotis? gregaria, Meek & Worthen.
Myalina kansasensis, Shumard.
recurvirostris, Meek & Worthen.
perattenuata, Meek & Hayden.
subquadrata, Shumard.
swallowi, McChesney.
Nucula parva, McChesney.
ventricosa, Hall.
Nuculana bellistriata (Stevens).
Pinna peracuta, Shumard.
Placunopsis carbonaria, Meek & Worthen.
Pleurophorus oblongus, Meek.
Schizodus ? curtus, Meek & Worthen.
harii, Miller.
wheeleri (Swallow).
Solenopsis solenoides (Geinitz).
Yoldia subscitula? (Meek & Hayden).

Gasteropods—

Aclisina minuta (Stevens).
robusta (Stevens).
stevensana (Meek & Worthen).
Anomphalus rotulus, Meek & Worthen.
Bellerophon bellus, Keyes.
crassus, Meek & Worthen.
marcouanus, Geinitz.
meekianus, Swallow.
montfortianus, Norwood & Pratten.
nodocarinatus, Hall.
percarinatus, Conrad.
stevensianus, McChesney.
urii, Fleming.

Bulimorpha ? inornata (Meek & Worthen).
Capulus parvus, Swallow.
Conularia crustula, White.
Dentalium meekianum, Geinitz.
Eulima ? peracuta, Meek & Worthen.
Loxonema multicosta, Meek & Worthen.
    scitulum, Meek & Worthen.
Murchisonia terebra, White.
Naticopsis ventricosa (Norwood & Pratten).
Pleurotomaria brazoensis, Shumard.
    broadheadi, White.
    carbonaria, Norwood & Pratten.
    coniformis, Worthen.
    coxana, Meek & Worthen.
    grayvillensis, Norwood & Pratten.
    illinoisensis, Worthen.
    missouriensis (Swallow).
    monilifera (White).
    perhumerosa, Meek.
    sphærulata, Conrad.
    speciosa, Meek & Worthen.
    subscalaris, Meek & Worthen.
    tabulata (Conrad).
    turbiniformis, Meek & Worthen.
    valvatiformis, Meek & Worthen.
Soleniscus brevis (White).
    gracilis (Cox).
    missouriensis (Swallow).
    newberryi (Stevens).
    paulidinæformis (Hall).
Sphærodoma medialis (Meek & Worthen).
    primogenia (Conrad).
    ponderosa (Swallow).
Strophostylus remex (White).
    nana (Meek & Worthen).
    peoriensis (McChesney).
Straparollus catilloides (Conrad).
    pernodosus, Meek & Worthen.
    subquadratus, Meek & Worthen.
Trachydomia nodosum (Meek & Worthen).
    wheeleri (Swallow).

CEPHALOPODS—

Goniatites minimus, Shumard.
    planorbiformis, Shumard.
    politus, Shumard.
Metaceras caviforme (Hyatt).
    sangamonensis, Meek & Worthen.

Nautilus forbesianus, McChesney.
missouriensis, Swallow.
occidentalis, Swallow.
ponderosus, White.
winslowi, Meek & Worthen.
Orthoceras rushense, McChesney.
occidentale, Swallow.

VERTEBRATES—

Orthopleurodus carbonarius, Newberry & Worthen.
Sandalodus lævissimus, Newberry & Worthen.

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PLATE XII.

EXPLANATION OF PLATE XII.

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FIG. 1.		*Fusulina cylindrica*	102
	1a.	Small fragment of limestone with shells embedded.	
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		Carboniferous, Upper Coal Measures.	
FIG. 2		*Receptaculites oweni*	103
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		Devonian, Hamilton limestone. (Mus. Mo. Geol. Sur.)	
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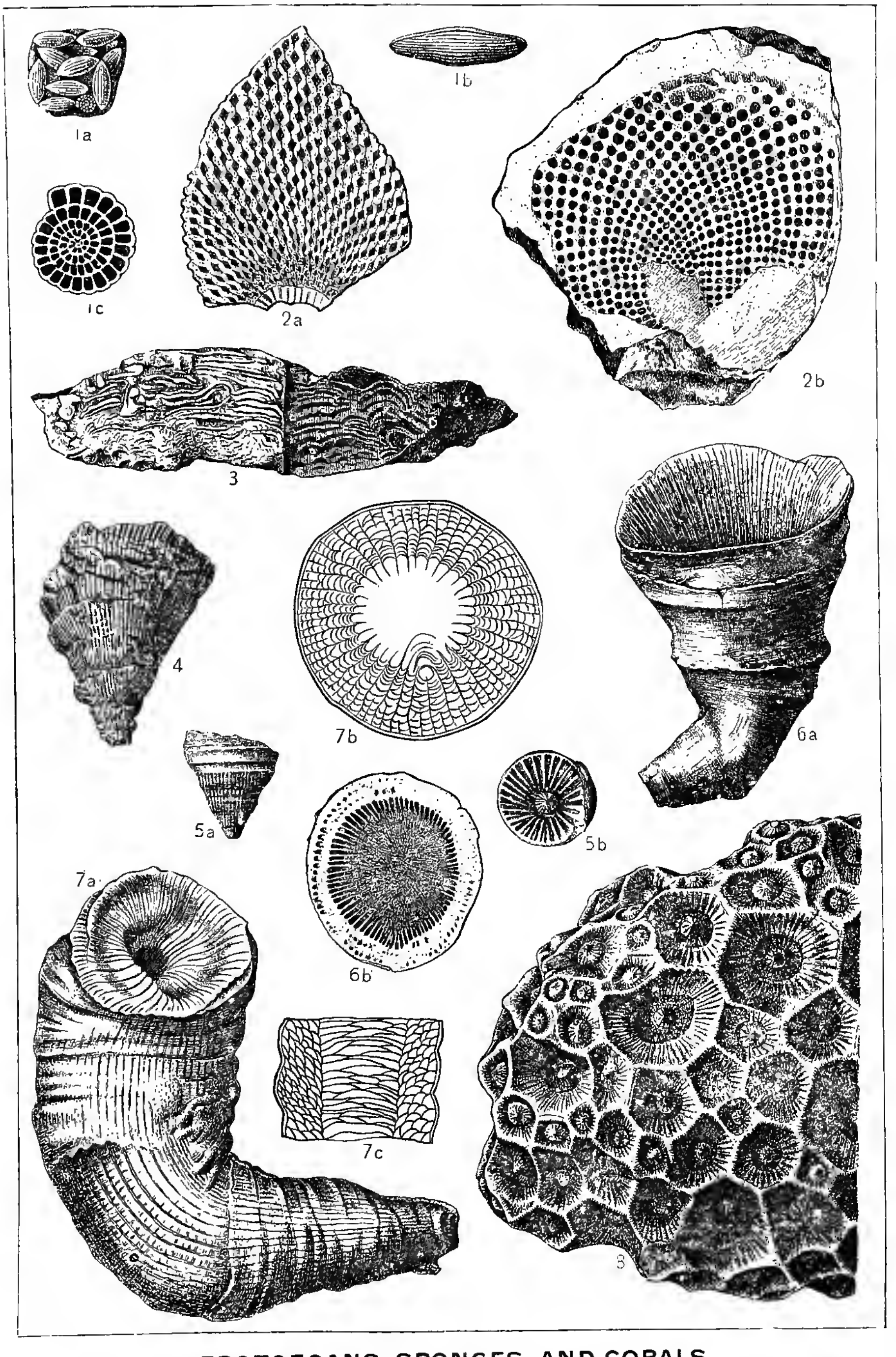
		Carboniferous, Upper Coal Measures.	
FIG 8		*Lithostrotion mammillare*	106
		Part of large specimen. (Mus. Mo. Geol. Sur.)	
		Carboniferous, Saint Louis limestone.	



PROTOZOANS, SPONGES AND CORALS.

PLATE XIII.

Explanation of Plate XIII.

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FIG. 1. *Amplexus blairi* 108
Longitudinal section. (Mus. Mo. Geol. Sur)
Carboniferous, Burlington limestone.

FIG. 2. *Amplexus yandelli?* 108
Lateral view of a well-preserved specimen. (Mus. Mo. Geol. Sur.)
Carboniferous, Kinderhook limestone.

FIG. 3. *Columnaria stellata* 116
A medium-sized mass. (Mus. Mo. Geol. Sur.)
Silurian, Trenton limestone.

FIG. 4. *Zaphrentis acuta* 109
Lateral view. (Mus. Mo. Geol. Sur.)
Carboniferous, Kinderhook (Louisiana) limestone.

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FIG. 6. *Zaphrentis elliptica* 111
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6b. View of same from above.
Carboniferous, Burlington limestone.

FIG. 7. *Campophyllum torquium* 107
An unusually large and twisted specimen. (Hare collection.)
Carboniferous, Upper Coal Measures.

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Carboniferous, Upper Coal Measures.

FIG. 9. *Streptelasma corniculum* 117
Lateral aspect. (Mus. Mo. Geol. Sur.)
Silurian, Trenton limestone.

FIG. 10. *Zaphrentis tenella* 111
An average-sized example. (Mus. Mo Geol. Sur.)
Carboniferous, Keokuk limestone.

FIG. 11. *Hadrophyllum glans* 116
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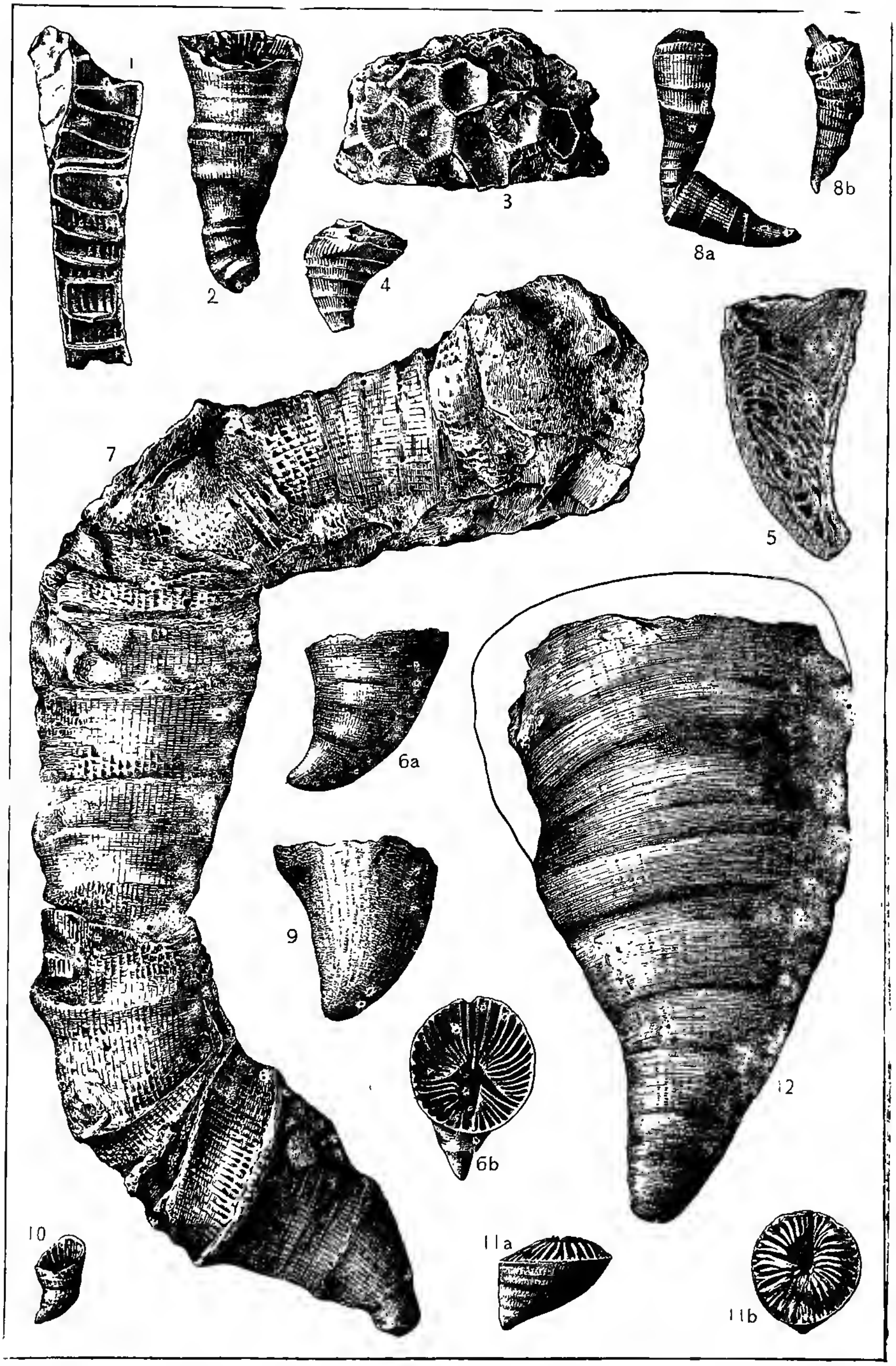
Carboniferous, Burlington limestone.

FIG. 12. *Zaphrentis dalei* 113
A large example. (Mus. Mo. Geol. Sur.)
Carboniferous, Keokuk limestone.



CORALS.

PLATE XIV.

Explanation of Plate XIV.

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FIG. 1. *Palæacis obtusa* 118

1a. View from above. (Keyes collection.)

1b. Same from side.

Carboniferous, Keokuk limestone.

FIG. 2. *Favosites favosa* 120

Small portion of a very large mass. (Mus. Mo. Geol. Sur.)

Silurian, Niagara ? oolite.

FIG. 3. *Favosites hemispherica* 120

A medium sized corallum. (Mus. Mo. Geol. Sur.)

Silurian, Niagara limestone.

FIG. 4. *Cystophyllum americanum* 117

4a. Lateral view. (Mus. Mo. Geol. Sur.)

4b. Longitudinal section of another specimen (same cabinet).

Devonian, Callaway limestone.

FIG. 5. *Syringopora sp?* 122

Portion of a large mass. (Mus. Mo. Geol. Sur.)

Carboniferous, Kinderhook limestone.

FIG. 6. *Syringopora harveyi* 121

6a. Part of a large specimen. (Mus. Mo. Geol. Sur.)

Carboniferous, Keokuk limestone.

6b. Syringopora multattenuata ; cross-section.

Carboniferous, Coal Measures.

FIG. 7. *Strictopora carbonaria* 121

View of part of branch. (Mus. Mo. Geol. Sur.)

Carboniferous, Burlington limestone.

FIG. 8. *Aulopora gracilis* 123

Type specimen. (Mus. Mo. Geol. Sur)

Carboniferous, Burlington limestone.

FIG. 9. *Chonophyllum sedaliense* 116

Type specimen. (After White)

Carboniferous, Chouteau (Kinderhook) limestone.

FIG. 10. *Conopterium effusum* 118

A representative example. (Mus. Mo. Geol. Sur.)

Carboniferous, Kinderhook limestone.

FIG. 11. *Clistopora placenta* 119

View from above. (Mus. Mo. Geol. Sur.)

Carboniferous, Chouteau (Kinderhook) limestone.

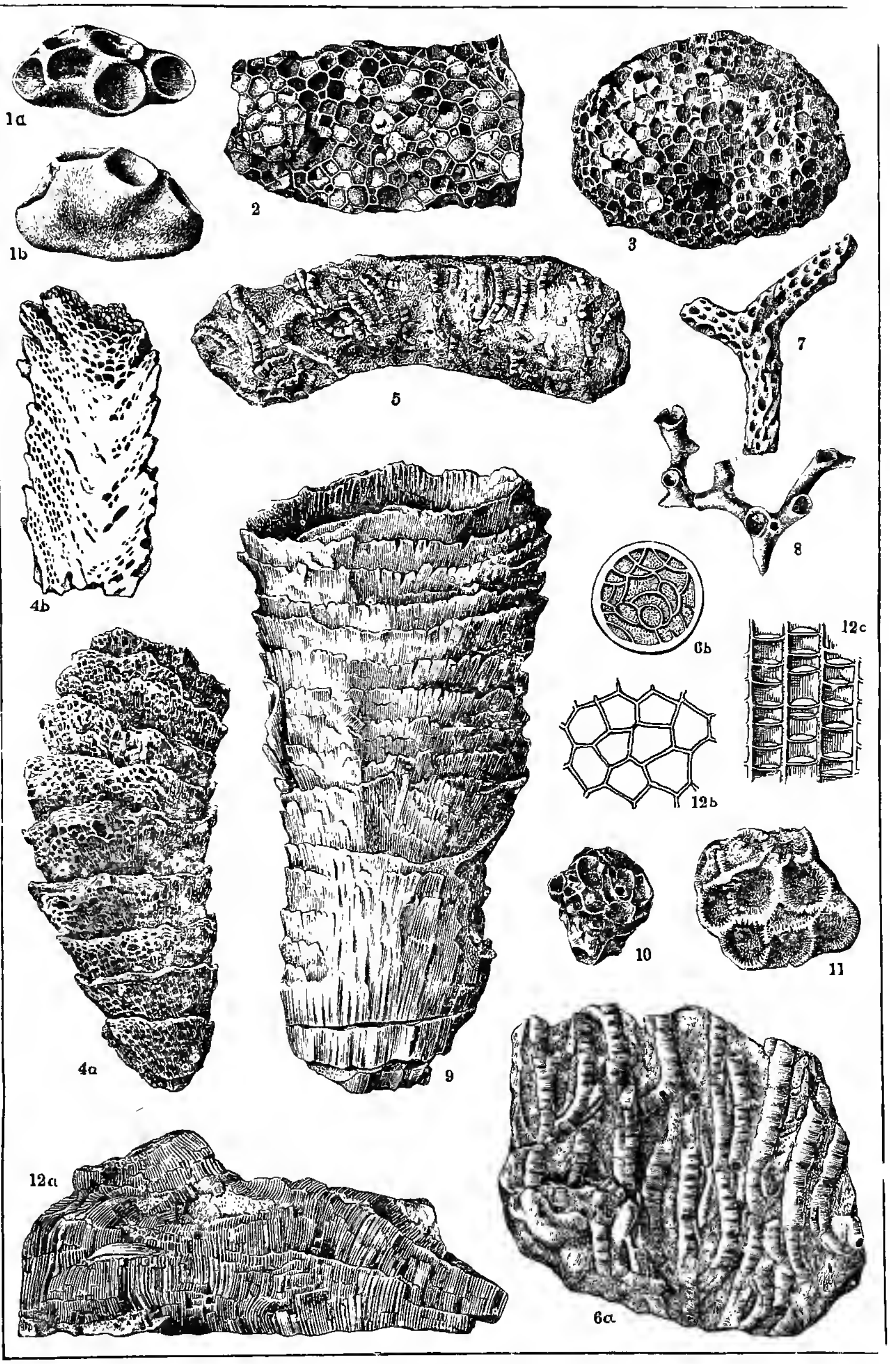
FIG. 12. *Chætetes milleporaceus* 123

12a. Part of large mass (Mus. Mo. Geol. Sur.).

12b. Cross-section of coralites (enlarged).

12c. Longitudinal section of same (enlarged).

Carboniferous, Upper Coal Measures.



CORALS.

PLATE XV.

EXPLANATION OF PLATE XV.

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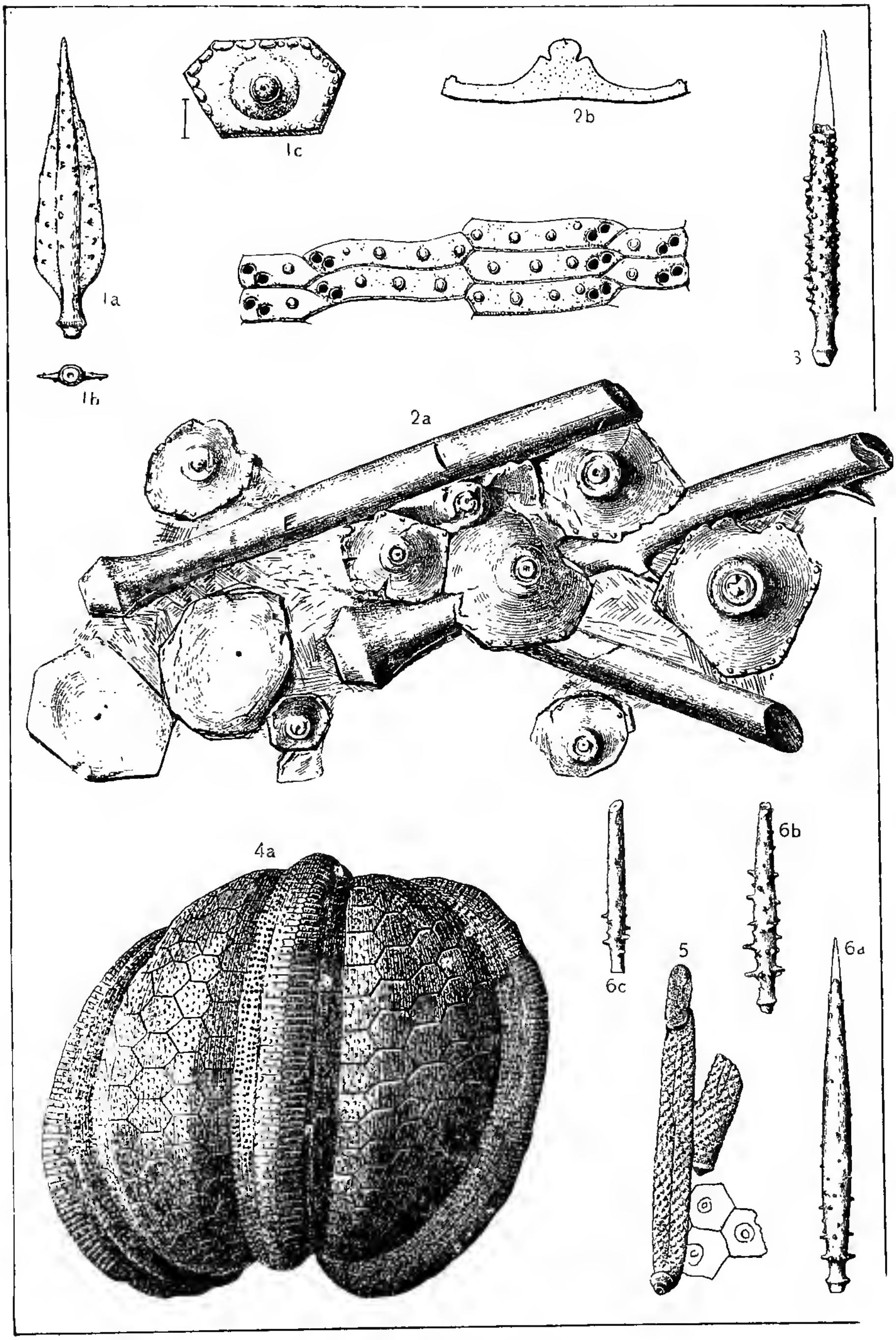
	Carboniferous, Upper Coal Measures.	
FIG. 4.	*Oligoporus mutatus*	126
4a.	Type specimen. (Cox collection.)	
4b.	Ambulacral plates (enlarged).	
	Carboniferous, Keokuk limestone.	
FIG. 5.	*Archæocidaris agassizi*	127
	Spines and plates. (Keyes collection)	
	Carboniferous, Burlington limestone.	
FIG. 6.	*Archæocidaris dininnii*	130
	Spines (After White)	
	Carboniferous, Upper Coal Measures.	



ECHINOIDS.

PLATE XVI.

EXPLANATION OF PLATE XVI.

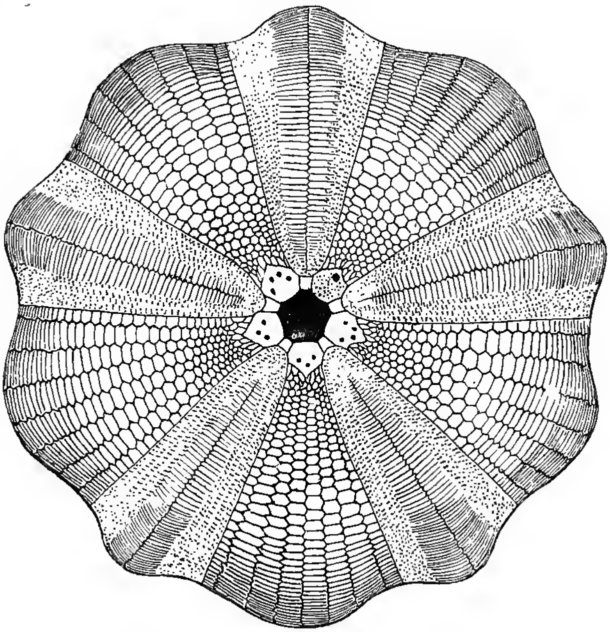
Page

FIG. 1. *Melonites multipora* 125

1a. Side view of nearly perfect specimen. (Wachsmuth collection.)

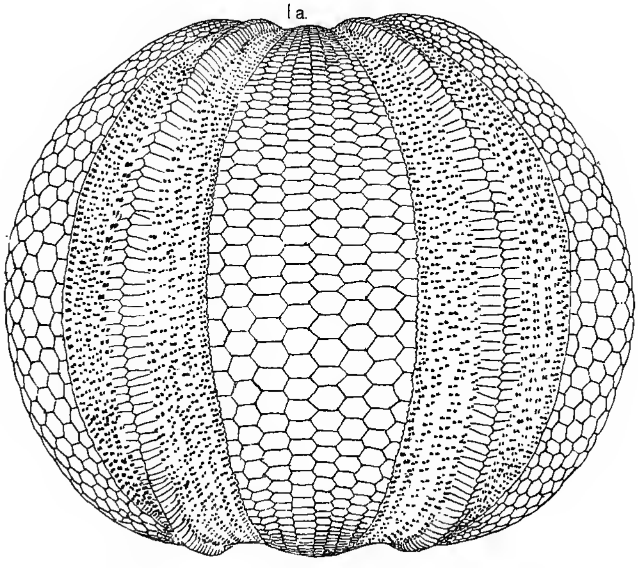
1b. Same from above.

Carboniferous, Saint Louis Limestone.



1b

1a.

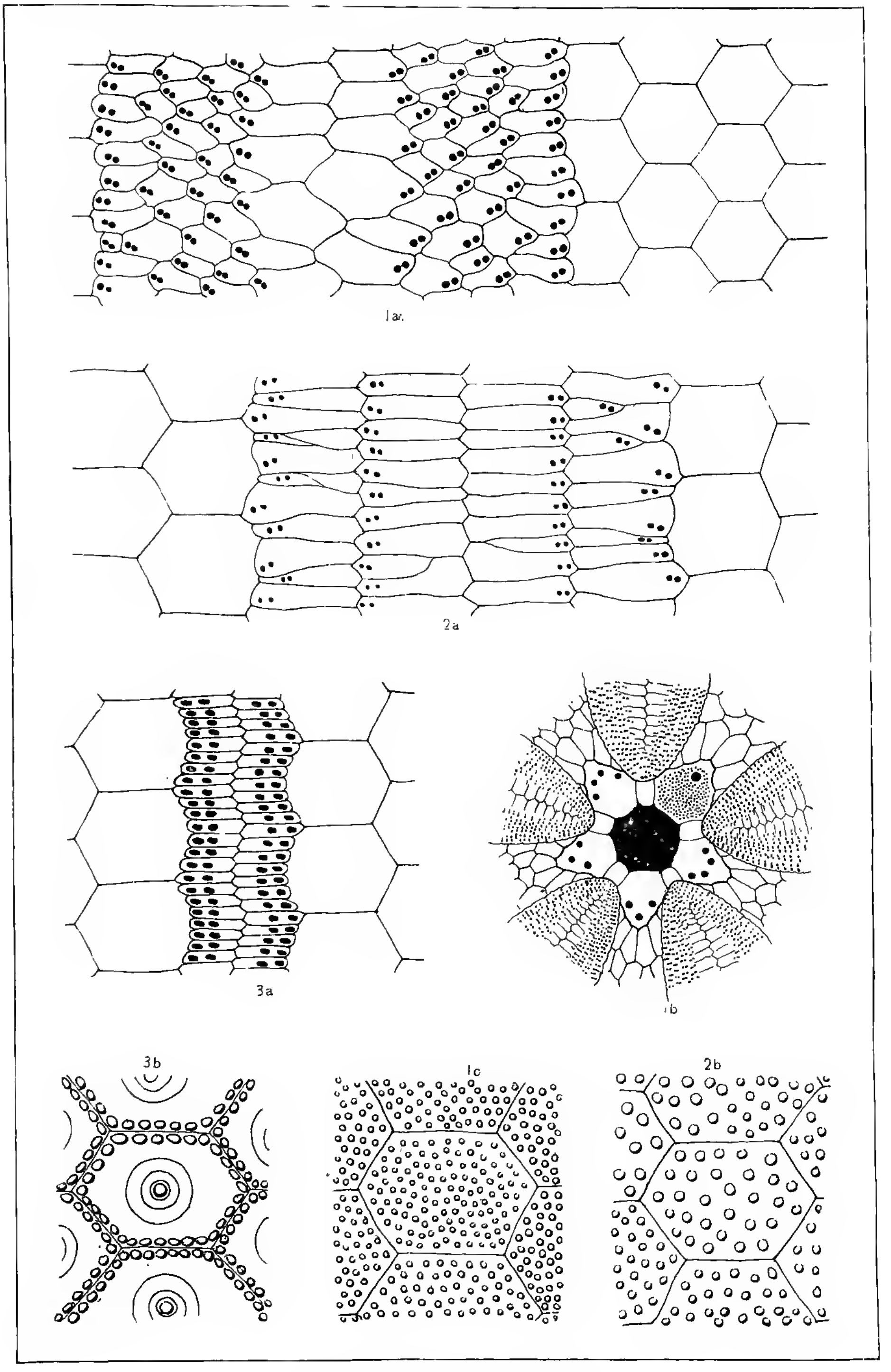


ECHINOIDS.

PLATE XVII.

EXPLANATION OF PLATE XVII.

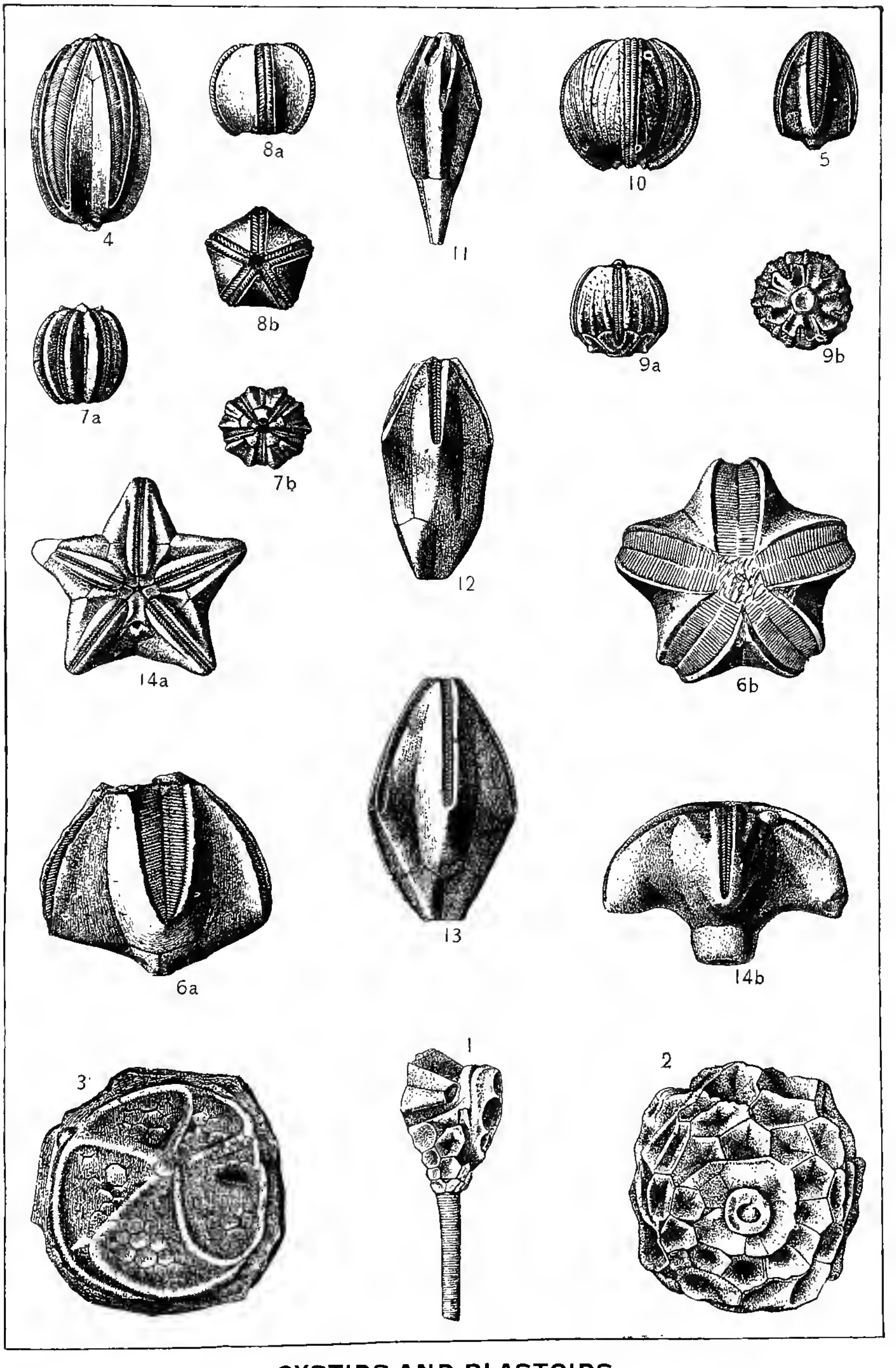
		Page
FIG. 1.	*Melonites multipora*	125
1a.	Ambulacrum (enlarged).	
1b.	Apical disk (enlarged).	
1c.	Interambulacral plate (enlarged).	
	Carboniferous, Saint Louis limestone.	
FIG. 2.	*Oligoporus danæ*	126
2a.	Ambulacral plates (enlarged).	
2b.	Interambulacral plates (enlargsd).	
	Carboniferous, Keokuk limestone.	
FIG. 3.	*Archæocidaris wortheni*	128
3a.	Ambulacral plates (enlarged).	
3b.	Interambulacral plates (enlarged).	
	Carboniferous, Saint Louis limestone.	



ECHINOIDS, STRUCTURE.

PLATE XVIII.

Explanation of Plate XVIII.

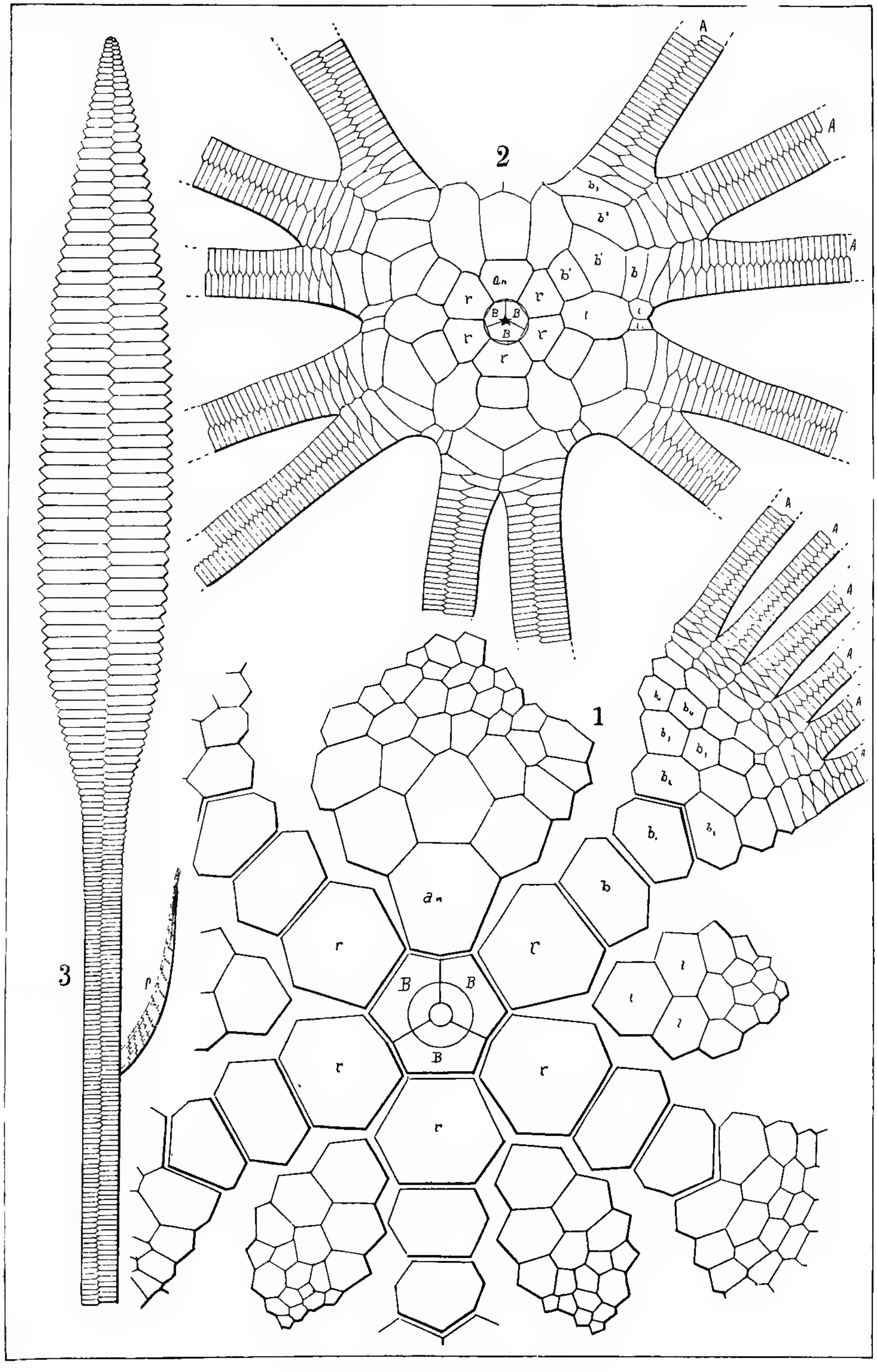


CYSTIDS AND BLASTOIDS.

PLATE XIX.

EXPLANATION OF PLATE XIX.

		Page
FIG. 1	*Megistocrinus evansi*	164
	Arrangement of plates.	
FIG. 2.	*Agaricocrinus americanus*	168
	Diagram of dorsal cup.	
FIG. 3.	*Eretmocrinus remibranchiatus*	178
	One of the arms.	



CRINOIDS, STRUCTURE.

PLATE XX.

EXPLANATION OF PLATE XX.

FIG. 1. *Batocrinus pyriformis.*
Diagram of dorsal cnp.

FIG. 2. *Actinocrinus proboscidialis.*
Arrangement of dorsal plates.

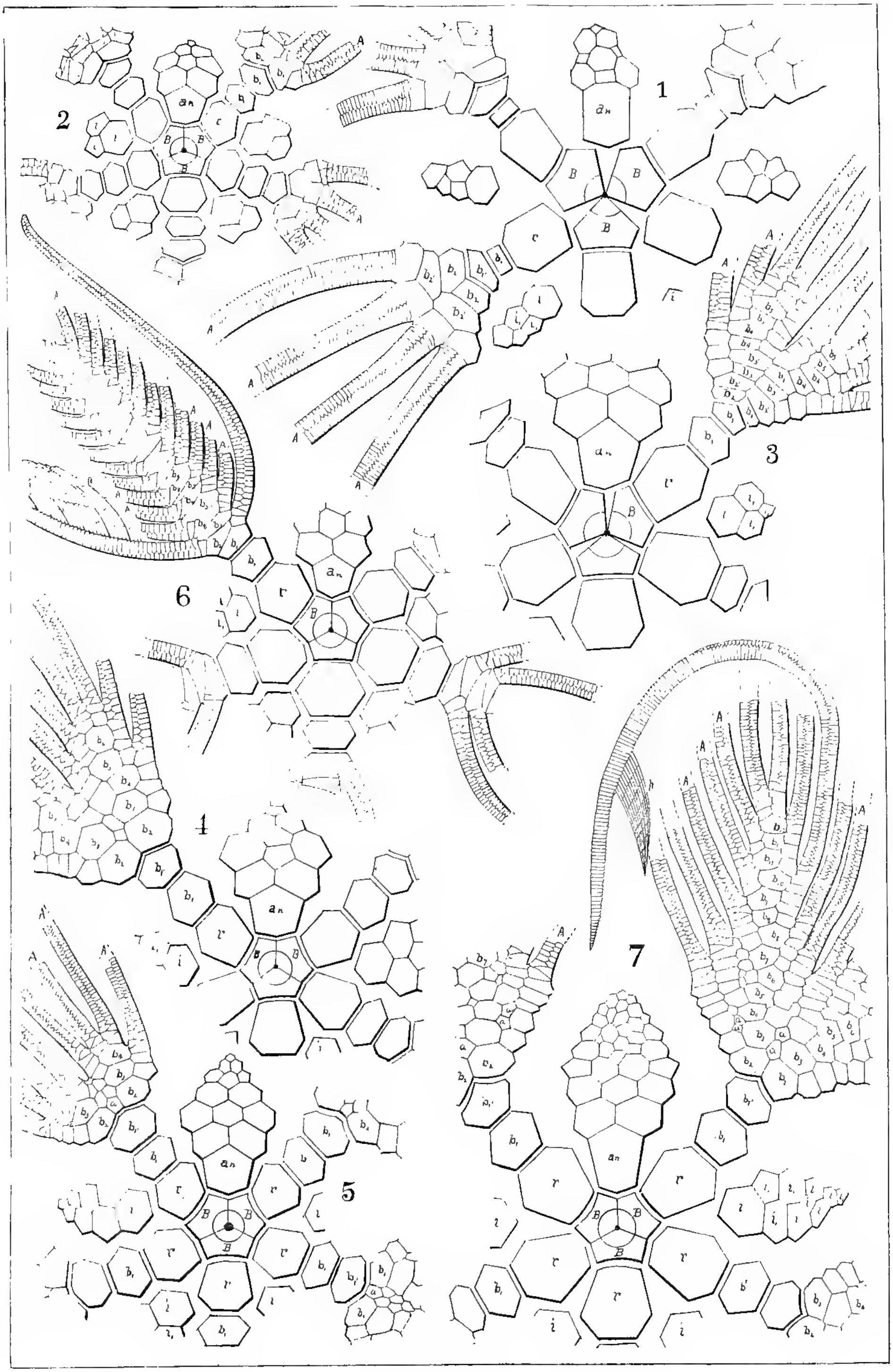
FIG. 3. *Actinocrinus multiradiatus.*
Diagram.

FIG. 4. *Teliocrinus umbrosus.*
Plan of the dorsal cup.

FIG. 5. *Physetocrinus ornatus.*
Arrangement of plates.

FIG. 6. *Steganocrinus sculptus.*
Diagram of dorsal cup.

FIG. 7. *Strotocrinus regalis.*
Diagram.



CRINOIDS.

PLATE XXI.

STRUCTURE OF THE STEMMED ECHINODERMS. PLATE XXI.

FIG. 1. *Batocrinus pyriformis.*
Outline of a nearly perfect specimen.

FIG. 2. *A typical Actinocrinoid*
Showing arrangement of basal plates.

FIG. 3. *Scaphiocrinus rusticellus.*
Outline of a nearly perfect specimen.

FIG. 4. *Platycrinus symmetricus.*
Ventral view. (Keyes collection.)

FIG. 5. *Platycrinoid.*
Basal plates.

FIG. 6. *Lyriocrinus mellissa.*
Ventral view. (Keyes collection.)

FIG. 7. *Cyathocrinoid.*
Basal plates.

FIG. 8. *Forbesiocrinus agassizi.*
A nearly perfect individual.

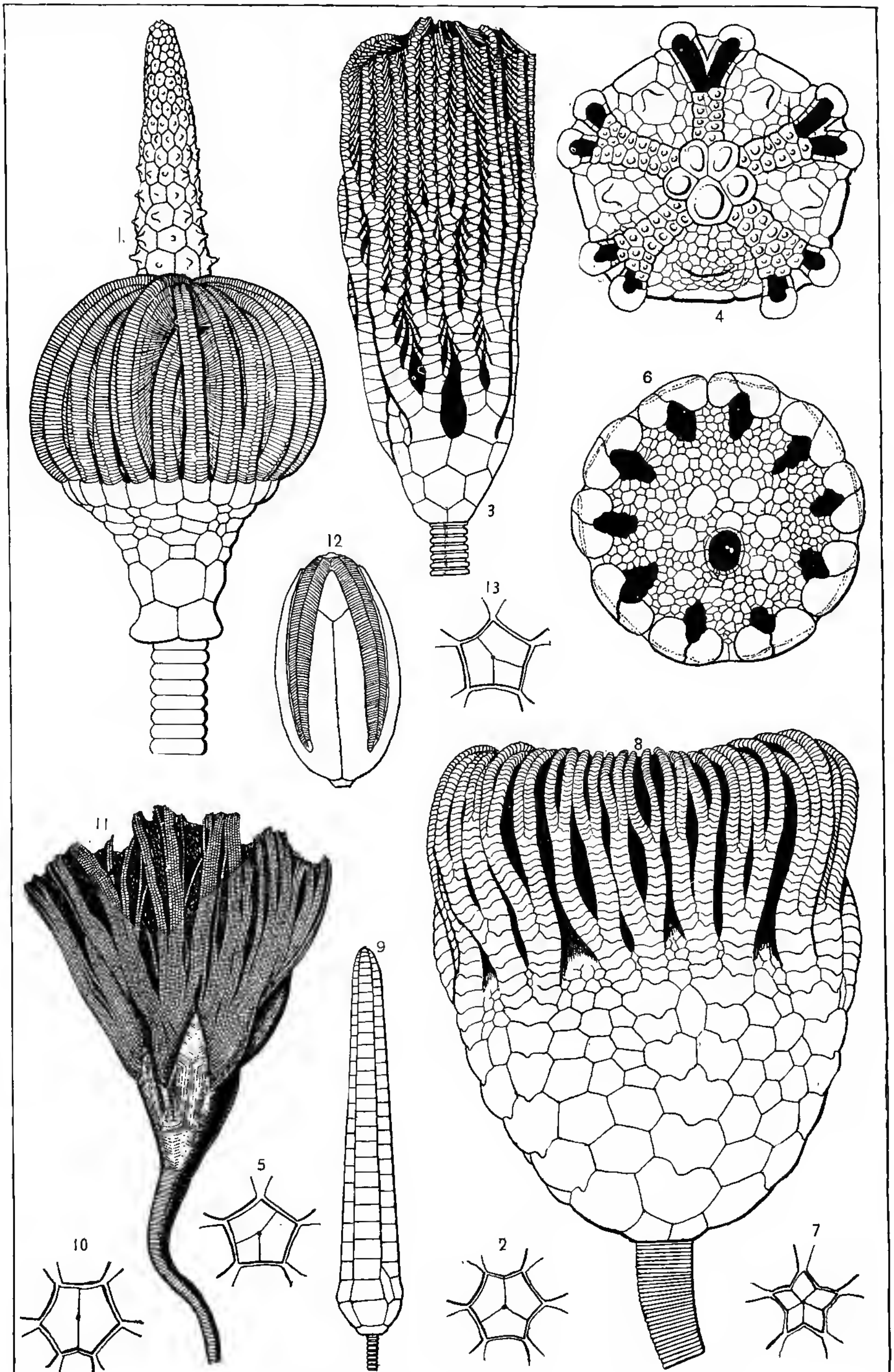
FIG. 9. *Symbathocrinus wortheni.*
A perfect crown.

FIG. 10. *Dichocrinoid.*
Diagram of basal cup.

FIG. 11. *Orophocrinus fusiformis.*
Shows pinnules. (Keyes collection.)

FIG. 12. *Pentremites elongatus.*
Lateral view.

FIG. 13 *Blastoid.*
Showing arrangement of basal plates.

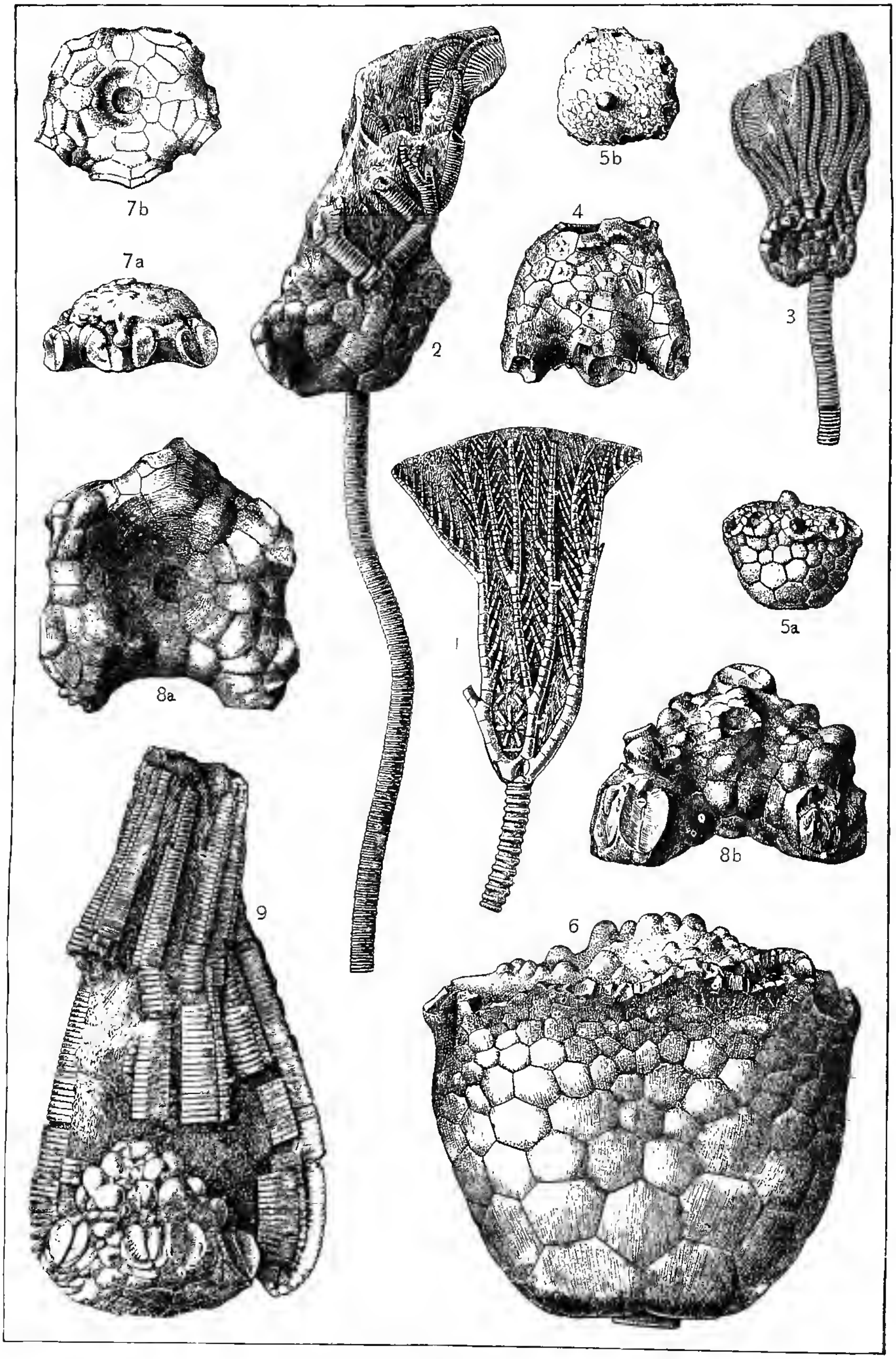


CRINOIDS.

PLATE XXII.

EXPLANATION OF PLATE XXII.

		Page
FIG. 1.	*Ptychocrinus splendens*	162
	Specimen with arms. (After Miller.)	
	Silurian, Trenton limestone.	
FIG. 2.	*Rhodocrinus sp ?*	
	Side view. (Britt collection.)	
	Carboniferous, Kinderhook limestone.	
FIG. 3.	*Rhodocrinus coxanus*	163
	Type specimen. (Cox collection)	
	Carboniferous, Keokuk limestone.	
FIG. 4.	*Amphoracrinus divergens*.	166
	Lateral view of calyx. (Keyes collection.)	
	Carboniferous, Lower Burlington limestone.	
FIG. 5.	*Megistocrinus brevicornis*	165
5a.	Lateral view. (Keyes collection.)	
5b.	Top view of same.	
	Carboniferous, Lower Burlington limestone.	
FIG. 6.	*Megistocrinus evansi*	164
	Lateral aspect of an average example. (Keyes collection.)	
	Carboniferous, Burlington limestone.	
FIG 7	*Agaricocrinus planoconvexus*	167
7a.	Side view. (Mus Mo. Geol. Sur.)	
7b.	Dorsal aspect of same.	
	Carboniferous, Lower Burlington limestone.	
FIG 8	*Agaricocrinus americanus*	168
8a.	Dorsal view of calyx. (Keyes collection.)	
8b.	Posterior view of same.	
	Carboniferous, Keokuk limestone.	
FIG 9.	*Agaricocrinus pentagonus*	167
	Specimen with arms. (Keyes collection.)	
	Carboniferous, Burlington limestone.	



CRINOIDS.

PLATE XXIII.

Explanation of Plate XXIII.

		Page
Fig. 1.	*Dorycrinus gouldi*	173
	Lateral aspect of calyx. (Keyes collection.)	
	Carboniferous, Keokuk limestone.	
Fig. 2.	*Dorycrinus unicornus*	169
	Anal view. (Keyes collection.)	
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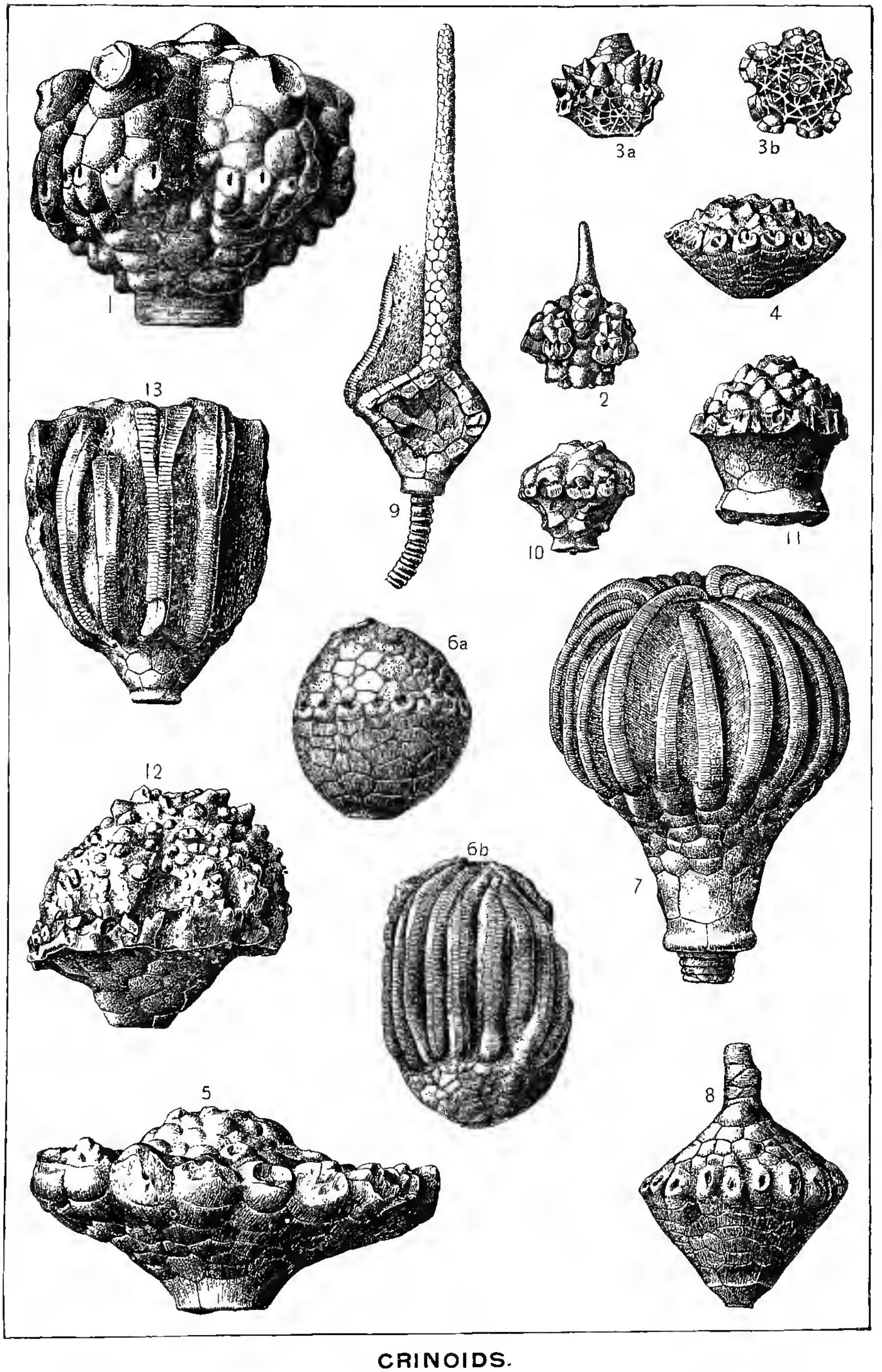
Fig. 3.	*Gennæocrinus trijugis*	174
3a.	Lateral view of calyx. (After Miller).	
3b.	Dorsal aspect of same.	
	Carboniferous, Kinderhook limestone.	
Fig. 4.	*Batocrinus calvini*	180
	Calyx of type specimen. (Rowley collection.)	
	Carboniferous, Burlington limestone.	
Fig. 5.	*Batocrinus trohiscus*	181
	Lateral view of calyx (Keyes collection.)	
	Carboniferous, Upper Burlington limestone.	
Fig. 6.	*Batocrinus rotundus*	182
6a.	Calyx. (Keyes collection.)	
6b.	Specimen with arms. (Same cabinet.)	
	Carboniferous, Upper Burlington limestone.	
Fig. 7.	*Batocrinus pyriformis*	182
	Specimen with arms. (Keyes collection.)	
	Carboniferous, Upper Burlington limestone.	
Fig. 8.	*Batocrinus laura*	182
	Side view of calyx. (Keyes collection.)	
	Carboniferous, Upper Burlington limestone.	
Fig. 9.	*Eretmocrinus verneuilianus*	177
	Specimen with anal tube preserved. (Keyes collection.)	
	Carboniferous, Upper Burlington limestone.	
Fig. 10.	*Eretmocrinus corbulis*	175
	Side view of calyx. (Keyes collection.)	
	Carboniferous, Lower Burlington limestone.	
Fig. 11.	*Eretmocrinus depressus*	176
	Type specimen. (Mus. Mo. Geol. Sur.)	
	Carboniferous, Lower Burlington limestone.	
Fig. 12.	*Eretmocrinus expansus*	175
	Type specimen. (Mus. Mo. Geol. Sur.)	
	Carboniferous, Lower Burlington limestone.	
Fig. 13.	*Eretmocrinus calyculoides*	177
	A specimen with arms. (Keyes collection.)	
	Carboniferous, Upper Burlington limestone.	



CRINOIDS.

PLATE XXIV.

EXPLANATION OF PLATE XXIV.

Page

FIG. 1. *Actinocrinus proboscidialis* 185
Specimen with arms. (Keyes collection)
Carboniferous, Lower Burlington limestone.

FIG. 2. *Actinocrinus glans* 189
2a. Ventral side of large specimen. (Keyes collection)
Carboniferous, Upper Burlington limestone

FIG. 3. *Actinocrinus verrucosus* 189
Side view of calyx. (Keyes collection.)
Carboniferous, Upper Burlington limestone.

FIG. 4. *Actinocrinus obesus* 187
Type specimen. (Mus. Mo. Geol. Sur)
Carboniferous, Lower Burlington limestone.

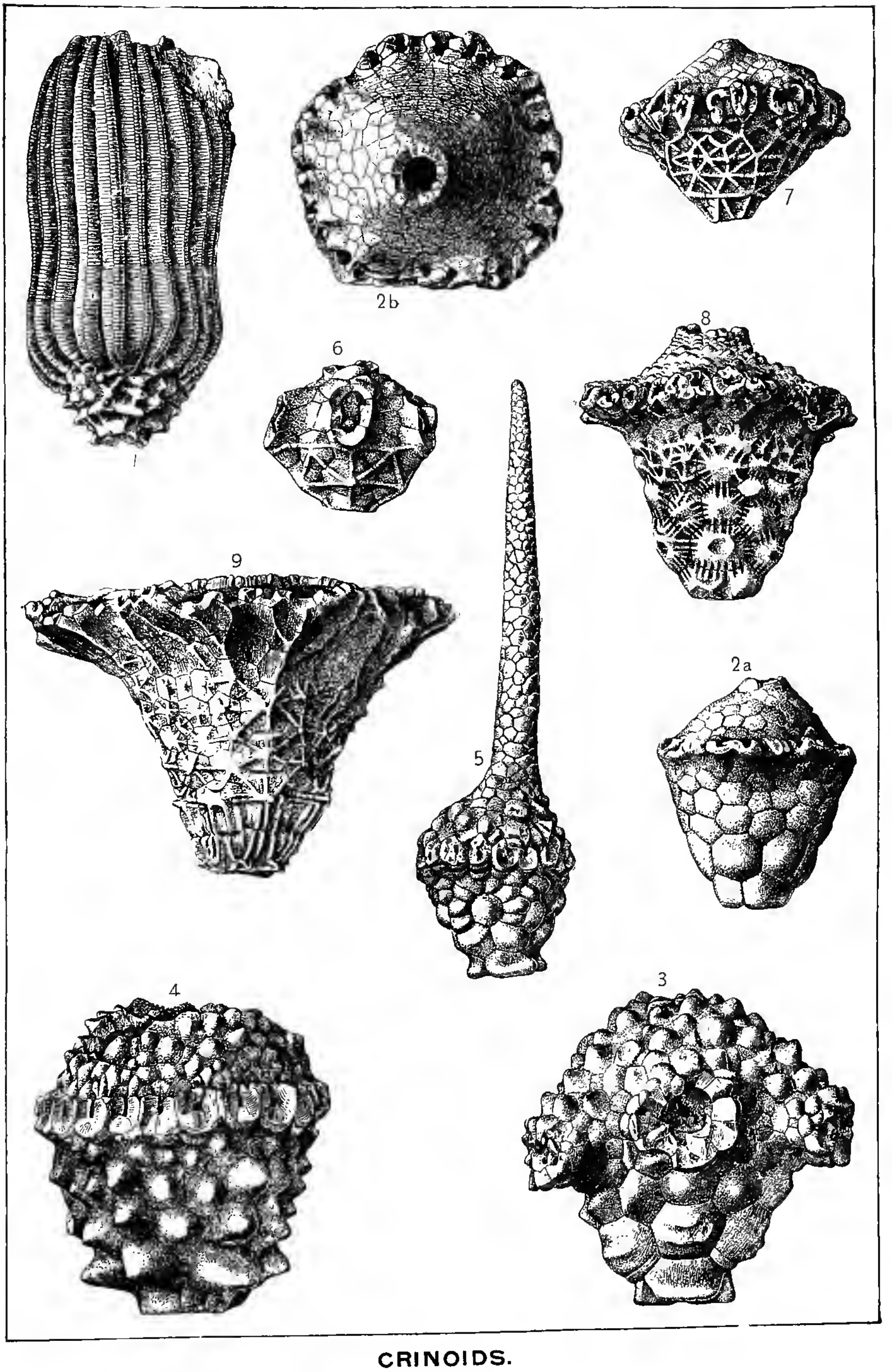
FIG. 5. *Batocrinus longirostris* 180
Specimen showing anal tube. (Keyes collection)
Carboniferous, Lower Burlington limestone

FIG. 6. *Steganocrinus pentagonus* 195
View of calyx. (Keyes collection.)
Carboniferous, Lower Burlington limestone

FIG. 7. *Physetocrinus ornatus* 192
Side aspect of calyx (Keyes collection.)
Carboniferous, Lower Burlington limestone

FIG. 8. *Teliocrinus liratus* 191
Lateral view of calyx. (Keyes collection)
Carboniferous, Upper Burlington limestone.

FIG. 9. *Strotocrinus regalis* 193
Calyx of well-preserved specimen. (Keyes collection)
Carboniferous, Upper Burlington limestone.



CRINOIDS.

PLATE XXV..

EXPLANATION OF PLATE XXV.

Page

FIG. 1. *Platycrinus saffordi* 202
Side view of dorsal cup. (Keyes collection.)
Carboniferous, Keokuk limestone.

FIG. 2. *Platycrinus americanus* 199
2a. Dorsal aspect of calyx. (Keyes collection)
2b. Side view of another specimen.
Carboniferous, Lower Burlington limestone.

FIG. 3. *Platycrinus halli* 201
Side view of dorsal cup. (Keyes collection.)
Carboniferous, Upper Burlington limestone.

FIG. 4. *Platycrinus discoideus* ....
Dorsal aspect of a specimen with arms. (Keyes collection.)
Carboniferous, Lower Burlington limestone.

FIG. 5. *Platycrinus pileiformis* 198
Side view of dorsal cup, showing grooves caused by Capulus shells. (Keyes collection.)
Carboniferous, Lower Burlington limestone.

FIG 6. *Talarocrinus simplex* 205
Calyx. (After Shumard.)
Carboniferous, Saint Louis limestone.

FIG 7. *Dichocrinus blairi* 204
Specimen with arms and part of stem. (After Miller)
Carboniferous, Keokuk limestone.

FIG. 8. *Dichocrinus striatus* 203
Calyx. (Keyes collection.)
Carboniferous, Lower Burlington limestone.

FIG 9. *Belemnocrinus sampsoni* 207
Type specimen. (After Miller.)
Carboniferous, Lower Burlington limestone.

FIG. 10. *Barycrinus sp. ?*
Specimen with arms. (Keyes collection.)
Carboniferous, Burlington limestone.

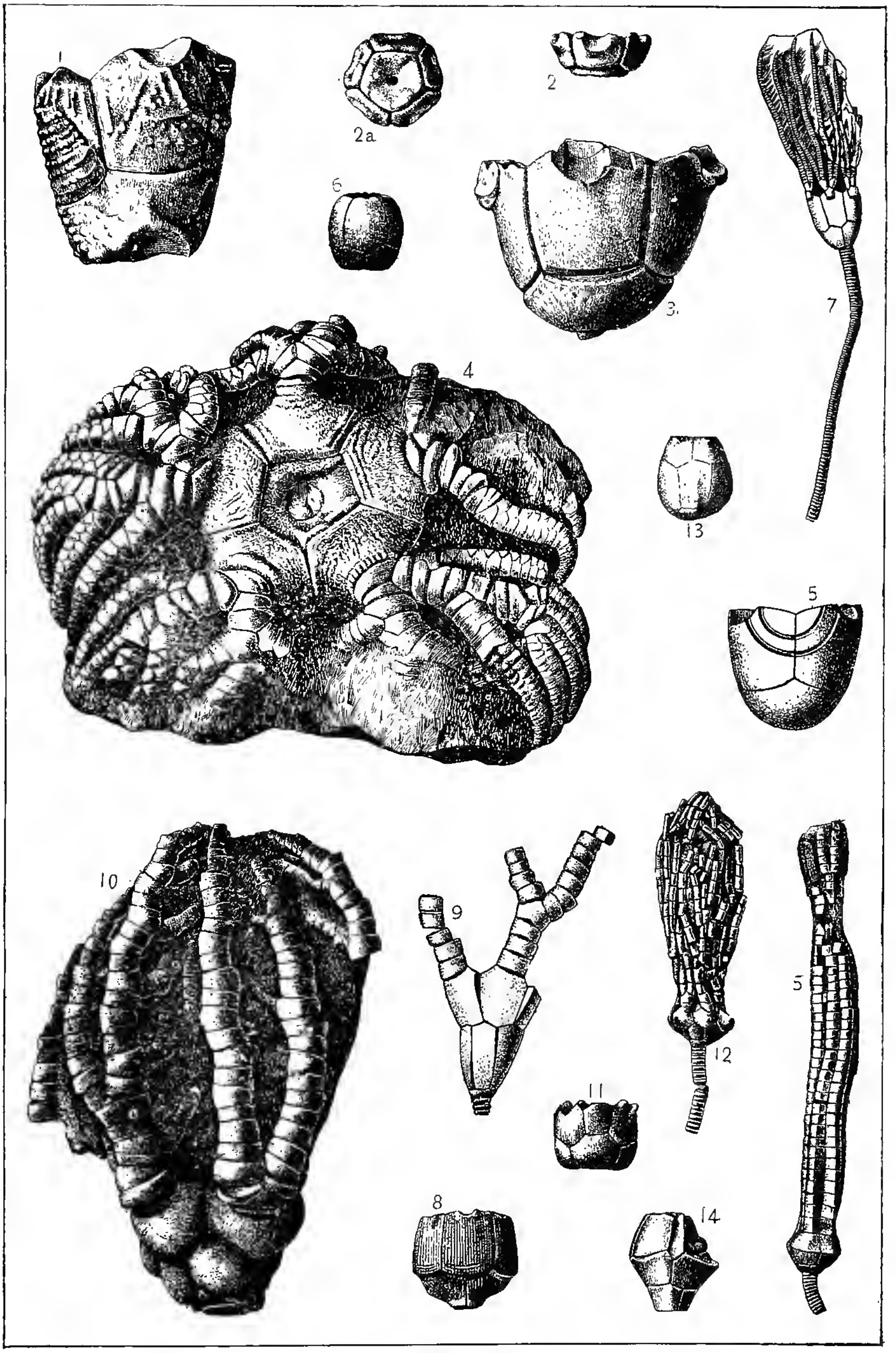
FIG. 11. *Cyathocrinus iowensis* 207
View of calyx. (Keyes collection.)
Carboniferous, Burlington limestone.

FIG. 12. *Cyathocrinus enormis* 208
A specimen with arms. (Keyes collection.)
Carboniferous, Lower Burlington limestone.

FIG. 13. *Lecythiocrinus olliculæformis* 208
View of calyx. (Hare collection.)
Carboniferous, Upper Coal Measures.

FIG. 14. *Symbathocrinus dentatus* 206
Posterior side of calyx. (Keyes collection.)
Carboniferous, Upper Burlington limestone.

FIG. 15. *Symbathocrinus wortheni* 206
Specimen with arms. (Keyes collection.)
Carboniferous, Lower Burlington limestone.

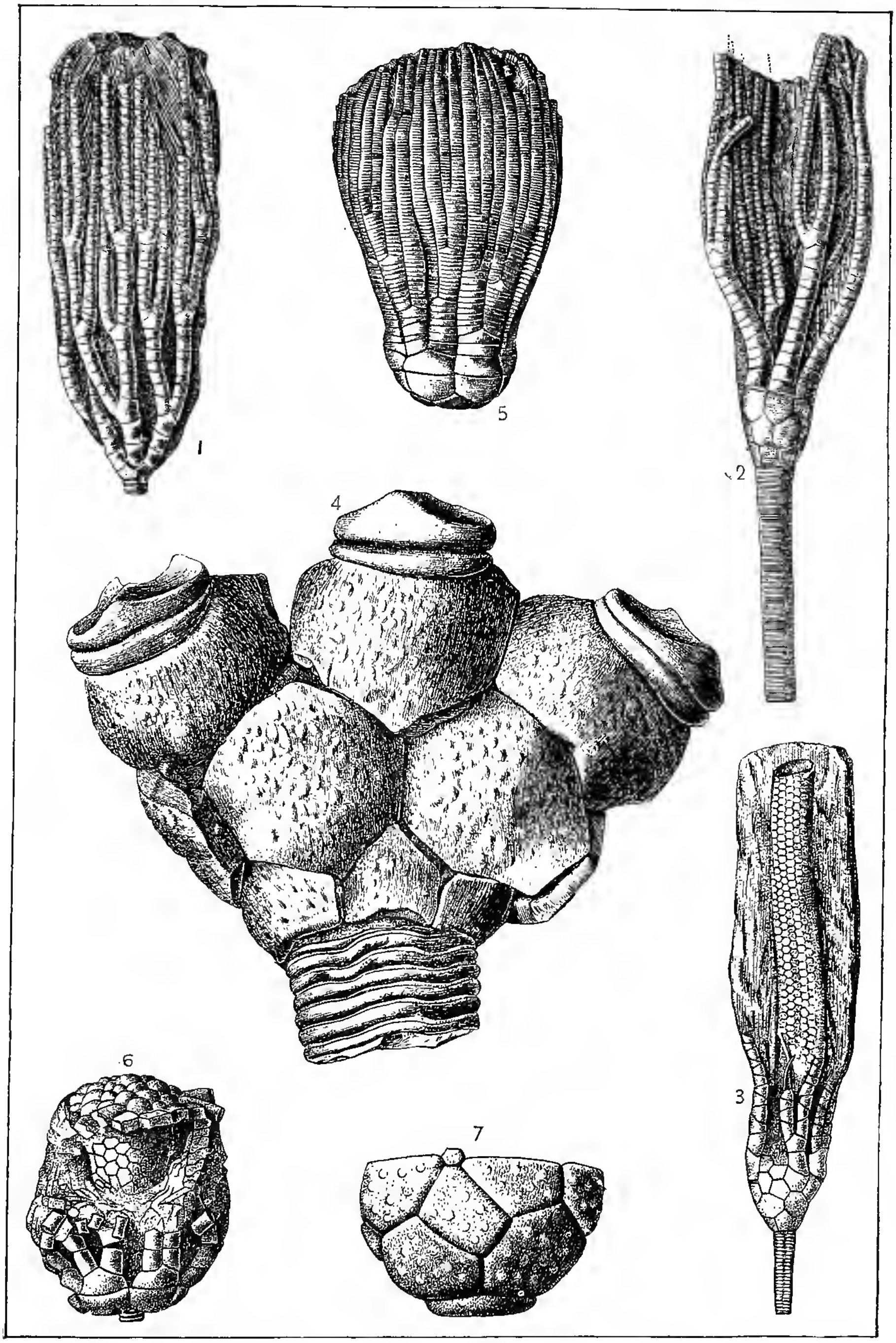


CRINOIDS.

PLATE XXVI.

Explanation of Plate XXVI.

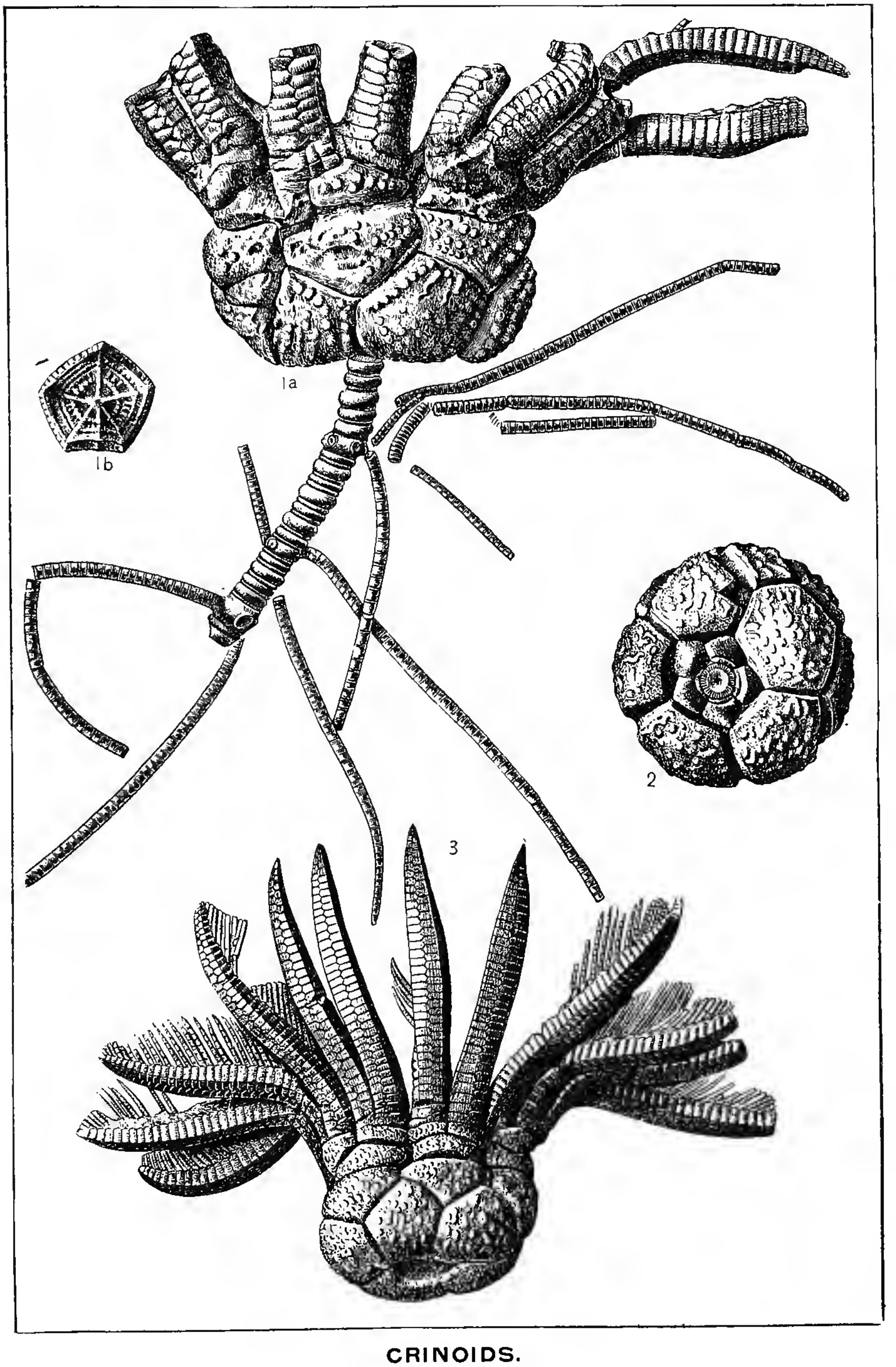
		Page
Fig. 1.	*Scaphiocrinus rusticellus*	212
	Specimen with arms (Keyes collection.)	
	Carboniferous, Lower Burlington limestone.	
Fig. 2.	*Scaphiocrinus missouriensis*	211
	Specimen showing arms and ventral sac. (Wachsmuth and Springer collection)	
	Carboniferous, Saint Louis limestone.	
Fig 3.	*Scytalocrinus vanhornei*	213
	Specimen showing ventral sac. (After Worthen)	
	Carboniferous, Saint Louis limestone.	
Fig 4.	*Barycrinus magnificus*	210
	Side view of calyx. (Cox collection)	
	Carboniferous, Keokuk limestone.	
Fig. 5	*Woodocrinus elegans*	214
	Example with arms. (Keyes collection)	
	Carboniferous, Upper Burlington limestone.	
Fig 6.	*Hydreionocrinus acanthophorus*	215
	Lateral view. (After Meek & Worthen.)	
	Carboniferous, Upper Coal Measures.	
Fig. 7.	*Cromyocrinus kansasensis*	216
	Posterior view of calyx. (Hare collection)	
	Carboniferous, Upper Coal Measures.	



CRINOIDS.

PLATE XXVII.

EXPLANATION OF PLATE XXVII.



CRINOIDS.

PLATE XXVIII.

EXPLANATION OF PLATE XXVIII.

Page

FIG 1. *Phialocrinus barydactylus* 220
Type specimen. (Hare collection.)
Carboniferous, Upper Coal Measures.

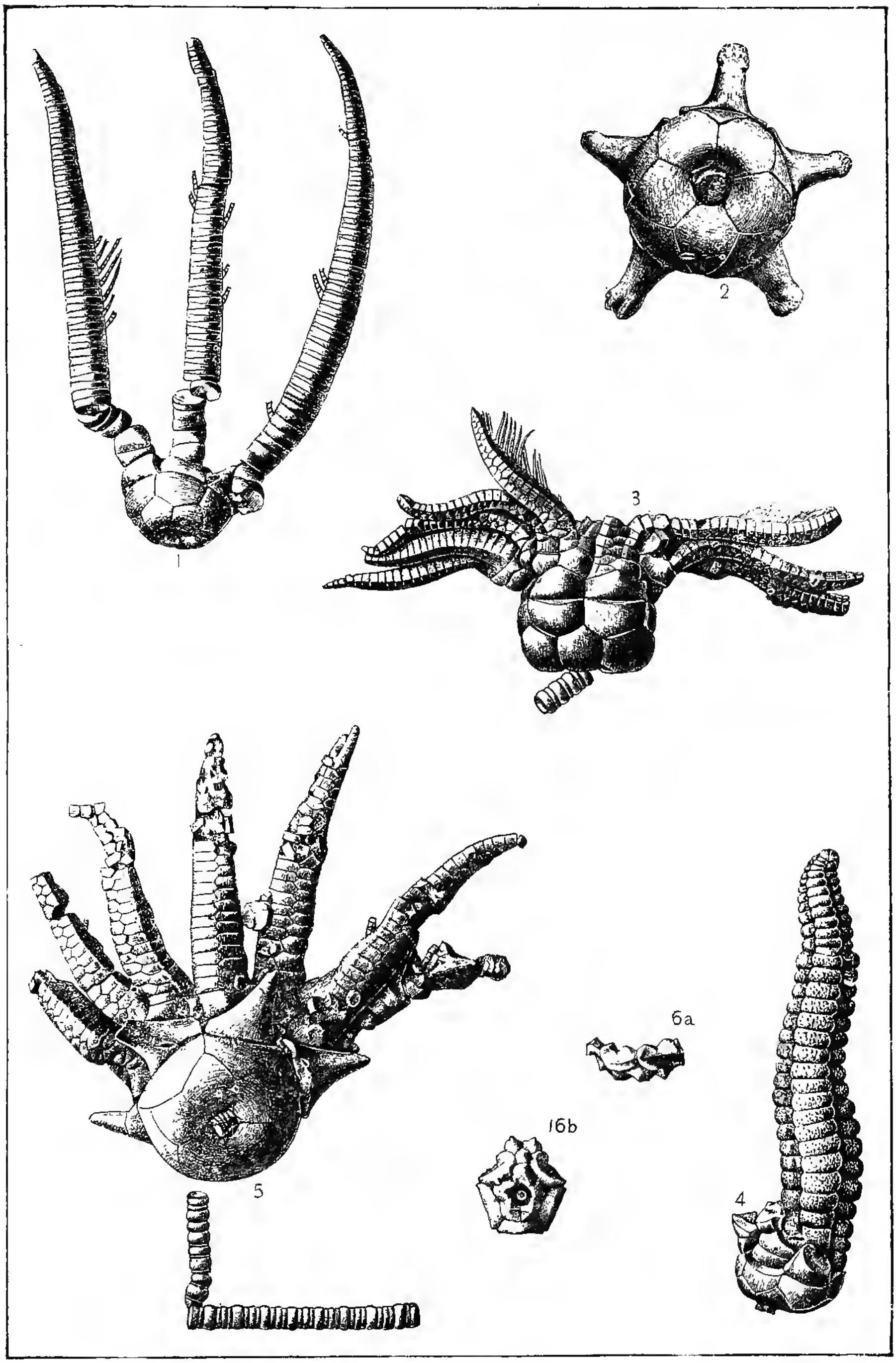
FIG 2. *Ceriocrinus hemisphericus* 220
Dorsal aspect of calyx. (Hare collection.)
Carboniferous, Upper Coal Measures.

FIG. 3. *Eupachycrinus harii*. 219
Type. (Hare collection.)
Carboniferous, Upper Coal Measures.

FIG. 4. *Phialocrinus magnificus* 220
Specimen showing ventral side. (Hare collection.)
Carboniferous, Upper Coal Measures.

FIG 5. *Ceriocrinus hemisphericus* 220
Specimen with arms. (Hare collection.)
Carboniferous, Upper Coal Measures.

FIG. 6. *Phialocrinus stillativus* 219
6a Side view of calyx. (Hare collection.)
6b. Dorsal aspect of same.
Carboniferous, Upper Coal Measures.



CRINOIDS.

PLATE XXIX.

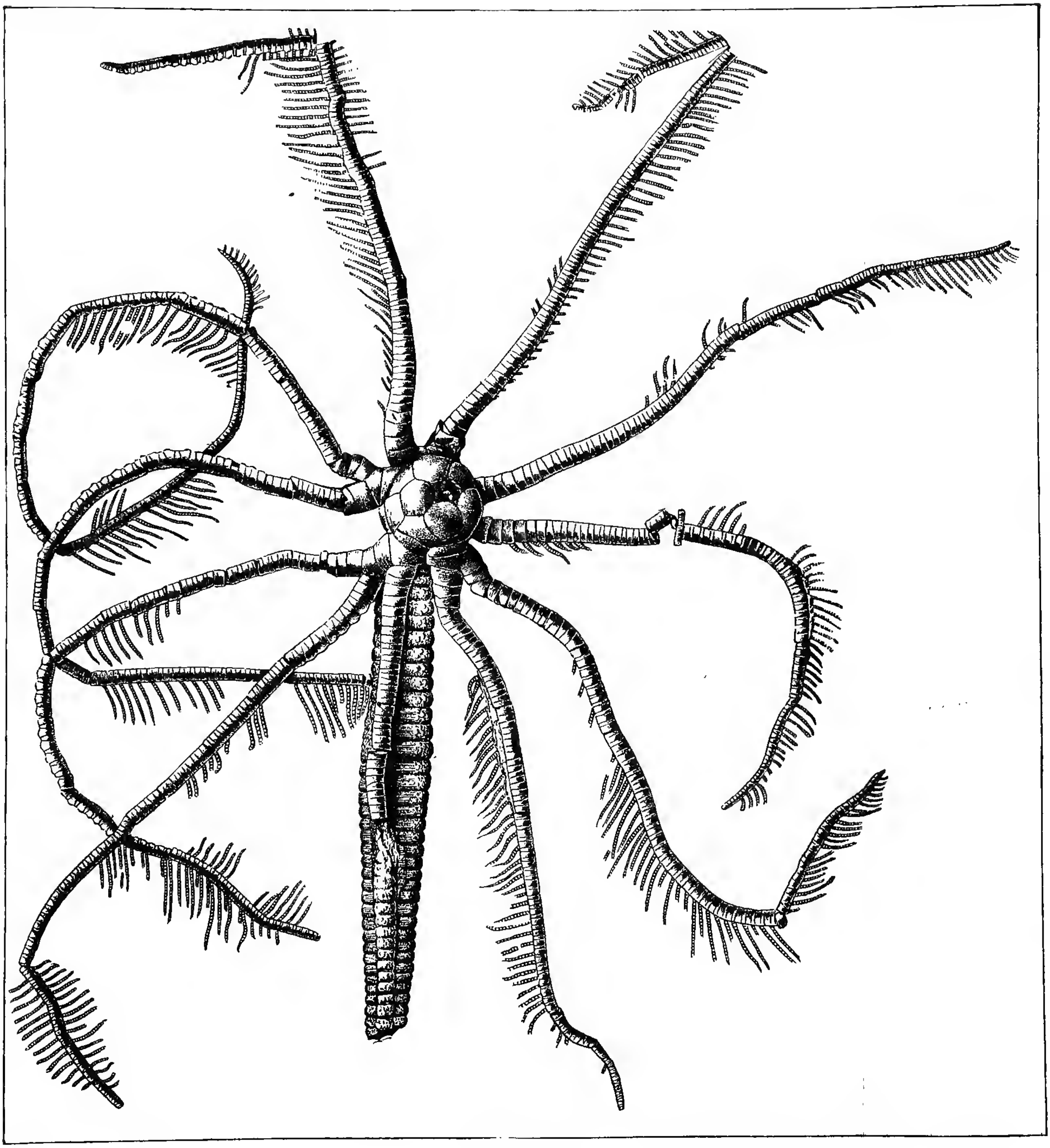
Explanation of Plate XXIX.

Page

Fig. 1. *Phialocrinus harii* 219

Specimen with arms and ventral sac. (Hare collection.)

Carboniferous, Upper Coal Measures.



.CRINOIDS.

PLATE XXX.

Explanation of Plate XXX.

		Page
Fig. 1.	*Eupachycrinus magister*	218
	Specimen with stem (Mus. Mo. Geol. Sur.)	
	Carboniferous, Upper Coal Measures.	
Fig 2.	*Onychocrinus monroensis*	224
	Type example. (After Meek & Worthen.)	
	Carboniferous, Keokuk limestone.	
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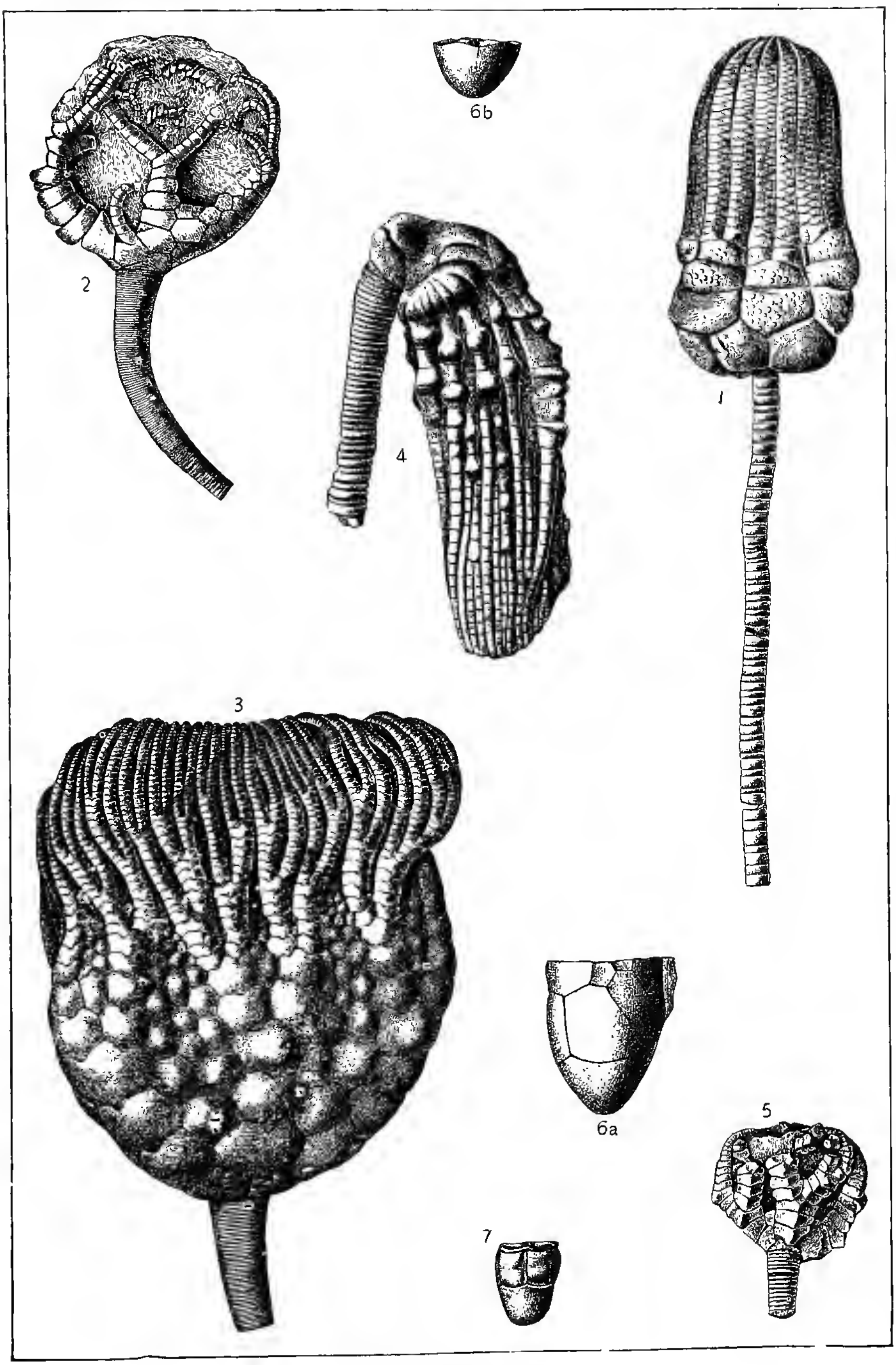
	Specimen somewhat flattened. (Keyes collection.)	
	Carboniferous, Burlington limestone.	
Fig. 4	*Calceocrinus tunicatus*	222
	Type of *C robustus*. (Cox collection.)	
	Carboniferous, Keokuk limestone.	
Fig. 5.	*Taxocrinus thiemi*.	223
	Lateral aspect. (Keyes collection.)	
	Carboniferous, Burlington limestone.	
Fig. 6.	*Agassizocrinus dactyliformis*	221
6a.	Calyx, posterior view.	
6b.	Basal cup. (Mus. Mo. Geol. Sur.)	
	Carboniferous, Kaskaskia limestone.	
Fig. 7.	*Ediocrinus pocilliformis*	221
	Type (After Meek & Worthen.)	
	Silurian.	



CRINOIDS

PLATE XXXI.

Explanation of Plate XXXI.

Slab, showing specimens of *Phialocrinus harii* from the Upper Coal Measures of Kansas City. Size about 9x12 inches. (Hare collection.)

CRINOIDS.

PLATE XXXII.

EXPLANATION OF PLATE XXXII.

Page

FIG 1. *Illænus insignis?* 227
- 1a. Dorsal aspect. (Rowley collection.)
- 1b. Portion of another example. (Mus. Mo. Geol. Sur.)

Silurian, Trenton limestone.

FIG. 2. *Cyphaspis girardeauensis* 228

Type. (After Shumard.)

Silurian, Girardeau limestone.

FIG 3. *Dalmanites tridentifera* 229
- 3a. Head of large specimen. (After Shumard.)
- 3b. Pygidium of smaller individual.

Silurian.

FIG 4. *Acidaspis halli* 230

Pygidium. (After Shumard.)

Silurian, Girardeau limestone.

FIG 5. *Calymene niagarensis*.

Lateral view. (Keyes collection.)

Silurian, Niagara limestone.

FIG 6. *Phillipsia tuberculata* 235

Pygidium. (Keyes collection.)

Carboniferous, Burlington limestone.

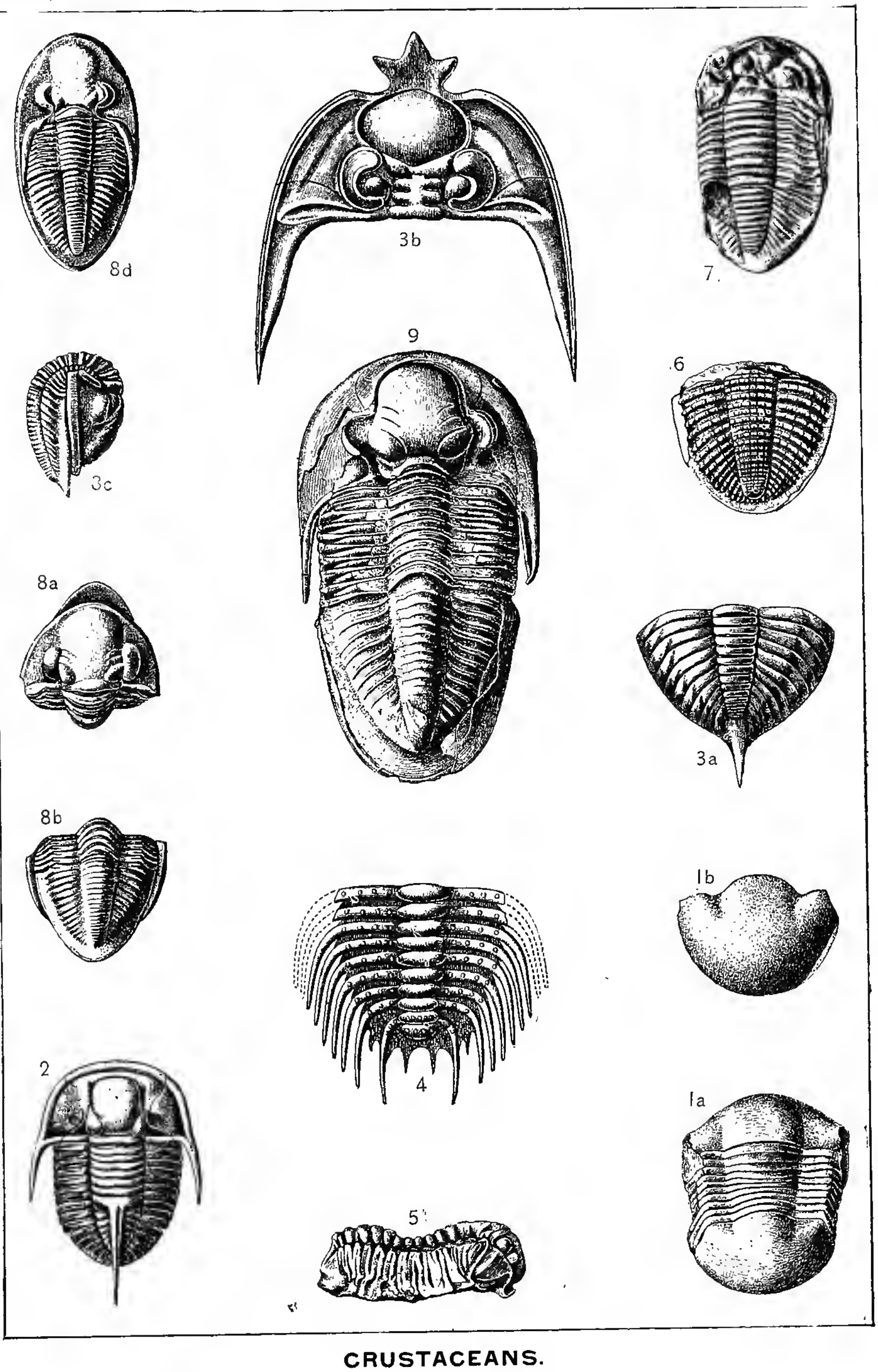
FIG 7. *Phillipsia portlockii* 236

Dorsal aspect. (Keyes collection.)

Carboniferous, Keokuk limestone.

FIG 8. *Phillipsia major* 238
- 8a. Buckler of coiled specimen. (Hare collection.)
- 8b. Pygidium of same.
- 8c. Lateral aspect of same.
- 8d. View of another example. (Same collection.)
- 8e. Large individual. (Mus. Kansas Univ.)

Carboniferous, Upper Coal Measures.



CRUSTACEANS.